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THE FEET OF INSECTS.

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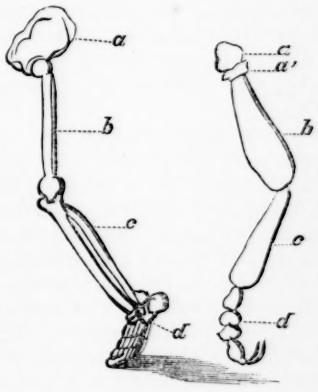
(*With a Tinted Plate.*)

It was suggested to me, some time ago, that a paper on the Feet of Insects might be acceptable to the readers of the Intellectual Observer; but, somewhat fearing that the subject was too well known, from the usual popular exhibitions of the foot of a fly or of a spider, I opened my collection of mounted insects, and began to look more carefully at their feet.

Small Coleoptera, Diptera, Hymenoptera, and Hemiptera were mounted whole, and parts of larger insects gave me several remarkable organs of motion. The feet, however, soon led the mind upward to the conclusion that, as the mechanism of the human hand or foot can only be understood by taking it in connection with the whole arm or leg, including the shoulder-blade and hip joint, so the feet of insects require an examination of the leg, and a knowledge of each joint, in order to appreciate the infinite variety, and perfect adaptation of every part to the wants and habits of these "living creatures."



I have said that the leg of an insect, and the vertebrate arm or leg have some resemblance in their composition; the leg is, perhaps, the best for comparison. They are both divided into four principal parts:—*a*, coxa, or hip; *b*, femur, or thigh; *c*, tibia, or shank; *d*, tarsus, or foot; *a** is an additional small joint,

* *Philos. Trans.* 1816, 325, t. xviii.

called a trochanter, which is so closely joined to the coxa as often to have no independent motion, and by some anatomists is considered merely as a part of that joint.

It is an interesting observation to make, that these joints have each been modified and varied, not only in the orders, but in the genera, and not in the genera only, but in the species, by shape and appendages that none but a careful naturalist can discover, but which, once observed, cannot fail to teach that pleasant lesson of the inexhaustible power, and infinite condescension of Him to whom indeed nothing is "little," no work too mean or lowly for a proper finish. In the larval, or imperfect state, insects have organs of locomotion, varied and curious enough to require a separate paper; the *apodous larvæ*, or those who walk without legs, have the most astonishing powers of progression, by muscular contraction and extension, by fleshy prominences, by anal hooks, or the use of mandibles, or by circles of spines round every segment of the body. The *pedate larvæ*, or those that move by means of legs, such as caterpillars and grubs of gnats, have spurious legs, tubercles armed with claws, retractile mamillæ; and the larvæ of water insects have organs appropriate to that element hereafter to be described.

Insects in their full development have six legs; the quasi-insects spiders, have eight; woodlice (*oniscidæ*) have fourteen; *Iulus maximus*, a great centipede has no less than 268; and it is a curious fact that a perfect centipede (*Iulus terrestris*) increases the number of its legs at every moult for two years: from twenty-six pairs, moulting, and obtaining thirty-six; moulting again, and possessing forty-three; until it prances along with 124 short but perfect legs, each terminating in a sharp claw.

Although I consider the whole leg of an insect worthy of minute attention, from the mere jointed appendage of a larva to the final form so helpful for many purposes—such as holding the insect's prey, cleansing its body, burrowing in the earth, building its habitation, or collecting its food—and although I cannot help drawing attention to its beautiful structure with all its complex machinery of muscles, nerves, and circulating fluid for the safe and swift movement of ball and socket joints, hinge joints, and rotatory articulation, yet as the last joint of the tarsi is usually considered the most interesting part, we shall confine our remarks as much as possible to the foot itself.

The fly, the spider, the cuckoo-spit, and water-beetles will furnish us with abundant illustrations of the subject.

FOOT OF THE FLY.

To study this part of our most common insect, and enter into the detail of its mechanism, we should possess a microscope of moderate power, and some prepared legs of either the *Scatophagus*, or dung-fly, or *Musca vomitoris*, or flesh-fly, and with a low power look at it as a whole. The tarsal joints are five, in all the Diptera; terminated in the fly by two black, strong claws and two Pulvilli, or white semi-transparent lobes, which are expansions of a membrane like parchment, apparently delicately fringed (fig. 1). These were formerly supposed to be suckers moveable in all directions, with a downy, convex surface and finely-granulated concave surface, which, being pressed closely to the plane of position, the air was supposed to be sufficiently expelled to produce the adhesion necessary to keep the fly from falling when walking upon glass, wall, or ceiling; the suckers contracting and dilating according to necessity.

Improvement in microscopes and a habit of careful investigation have led to a further discovery, first by Mr. Blackwall,* and then by Mr. Hepworth,* which proves this supposition to be an erroneous one.

They have ascertained that the delicate fringe of hair is itself the point of attachment, each hair being a minute tube, expanding at the tip into a disk or sucker, through which flows a viscid fluid, by means of which the fly's foot is attached to any dry surface so firmly as to require the action of those two strong claws to detach it again (fig. 1 *a*).

It was but a few days ago that I noticed a small house-fly jerking in a queer way upon the glass, as if in a fit of St. Vitus's dance, pulling up first one leg and then the other, but evidently unable to walk or detach itself from the glass. Upon a closer examination with a pocket-lens I saw from the appearance of certain white rings round the abdomen that the fly was really "very poorly," attacked with Empusa Muscæ—a disease to which they are very subject at this time of the year. This is an inward malady, arising from the growth of a fungus, which eventually consumes the whole viscera, and, doubtless, the muscles also, then breaks forth between the segments of the body, and the fly is seen sticking to the glass, surrounded by a halo of white dust—the spores of this fungus. The fly I was observing, weakened, doubtless, by the loss of some muscles, and the fluid continuing to flow from its suckers, it had no strength to contend with it.

The muscular power needful for the action of the claws must be considerable, when it is remembered that some flies run with such swiftness as to take 540 steps in a demi-second—equal to

* *Quarterly Journal of Microscopic Science*, 1854, vol. ii. p. 158.

the running of a man at the rate of twenty miles a minute. How astonishing, then, are the powers concealed within this tiny foot!

Nor is it the last joint of the tarsi only that accomplishes this feat; the flexor and extensor muscles, which are external to the bone in the claw of a cat, here lie within the crust of an insect's leg, and with their attendant nerves, and the life-giving circulation of vital fluid, attain their full development in the thickness of the femur, or thigh. Even as in the human arm or leg the fulness of elastic fibre denotes a strong-limbed man, so the shape of an insect's leg will give a pretty correct idea of its habits of leaping, or walking, or running; as, for instance, the remarkably *fast* fly, *Stenopteryx Hirundinis*, which infests our poor house-swallow. How robust are its thighs, and how strong are the toothed claws—no wonder it springs so deftly through, and clings so tightly to the downy feathers of the young bird. Beside this leg I have drawn one of the Tipulæ—long and slender, with small foot and hooked claw, such as is best adapted for an insect whose life is on the wing, or who only stalks along the grass to deposit its eggs. Observe, also, that the Stenopteryx has no large pulvillus; they would greatly impede this fly in its movements, therefore they are extremely small. Compare them with the long, large lobes of the house-fly, or *Asilus*, which have the habit of *resting* on walls or stems of trees (fig. 2); or with the foot of a *Leptis*—a pretty quiet fly, fond of repose in the sunshine of summer, where it is easily taken on the bark of forest trees; it has *three* lobes in each pulvillus, and by no means muscular legs (fig. 3).

The claws of Diptera have many modifications as well as the pulvillus. In the month of July, seeing our pony tormented by a very pretty little piebald fly (*Simulium elegans*) waving its white-banded fore-legs in an ecstasy of enjoyment as it refreshed itself with the warm blood of our "Black Prince," I caught one, and observed its variegated tibia, and that its claws were toothed with a small pulvillus, probably for running quickly over the horse and clinging to the hair (fig. 4).

Most of the Tipulæ, or gnat tribe, have toothed claws; they hang upon leaves, they rest upon grass and fern, and cling to water-plants or floating fragments on the water whenever they are commanded to deposit their eggs. The claw of the midge (*Ceratopogon*) is remarkably toothed and curved (figs. 10, 14, and 15). This is not the window midge (*Psychoda*), which requires, *and has*, a larger pulvillus and thicker legs for the hopping they indulge in, always zigzag, too, from right to left and left to right up the window pane.

The *Ceratopogon* are those beautiful but most annoying little gnats who dance in merry companies by river sides and on

marshy ground. Some of them are carnivorous, and, like the *Dolichopus* and *Empis*, flies who prey upon smaller insects, have the thighs armed with spines, as in fig. 13, by which the struggles of its prisoner are soon ended. I need not say that in this tribe the pulvillus is always very small, and often altogether absent.

But whilst we are looking at the foot of a fly, let us not pass unheeded the variations in the tarsal joints. Here is the leg of a merry little fellow of the Empis family (*Hilara cilipes*, fig. 13); he feeds chiefly on the nectar of flowers, and is easily recognized by his dilated fore-metatarsi, but he also enjoys a small fly or two, and has a sharp little proboscis on which to spit them and leisurely suck their juices. These pretty little Hilara, I cannot help talking of them; they assemble in myriads over the running rivulets and the calm bright waters of the Cherwell, revolving in horizontal or oblique circles, crossing each other in a mazy dance, sweeping away quite suddenly, as if impelled or chased by fairy foes, anon returning to their merry sport in the summer sunshine. These dilated tarsi belong only to the male, and are given that he may restrain the movements of his volatile mate.

Fig. 8 is the leg of *Bibeo marci*, a very abundant heavy black fly, found in meadows round London during the month of May, with a remarkable prolongation of the fore-tibia into a sharp spine, with which it retains its prey. Another species has a perfect coronet of spines round its tibia.

Figs. 7 and 9 are legs of those flies called *Syrphidæ*, which resemble small wasps, and hover over flowers with a peculiar vibration of their wings; the curved and toothed femur is for some special purpose, I doubt not, but I cannot tell what it is; they are honey-loving insects, and difficult to catch, from *springing* sideways very quickly.

I must now conclude a paper that is, I fear, too long already, with the foot and leg of a flea. The *Pulex irritans* is ranked with the Diptera now, though wingless, because of its suctorial apparatus allying it to the Gnat family.

No pulvillus, indeed, does this restless little pest require, but it wants muscular power in no ordinary degree to leap 200 times its length without any aid from wings, and therefore look at the long, large coxa, the stout femur, the spiny tibia, and strong claws; not only lobed, and long, and sharp; but striated (fig. 12 *c*), and crenated, and for hitching in blankets, and creeping, and clinging, and tickling,—finished to perfection.

THE ECONOMIC PRODUCTION OF ARTIFICIAL HEAT.

BY J. W. M'GAULEY.

THIS subject is of considerable importance, both in a domestic and an industrial point of view, but particularly in the latter, since the success of a manufacture must be greatly affected by the cost at which heat—that is, motive power—is procured. The supremacy which Great Britain has attained, as a manufacturing country, is mainly due to the abundance and excellence of her fuel, and to a skilful application of the advantages it has conferred. We cannot enter into all the details of this very extensive inquiry; but we shall lay before our readers some of the most useful facts and most practical deductions connected with it.

The purposes for which artificial heat is required may be conveniently divided into two classes: one of them relating to domestic economy, and having for its object the preservation or production of a proper temperature in apartments, and the preparation of food; and the other to the requirements of the arts and manufactures. Few climates are so genial as, at no part of the year, to demand artificial modes of warming habitations; none are altogether independent of heat for culinary purposes; and all civilized nations are desirous of promoting manufactures, which, when carried on extensively, must, to a greater or less extent, depend on the effect derived from heat. For, with the steam-engine, heat is really the moving power, the water being but a carrier of the forces developed by combustion, and the steam but the most convenient medium for obtaining them. Such an investigation as the present includes also a consideration of the different species of fuel, and their most effective application to practical purposes: these various points, therefore, shall more or less be kept in view in what we are to say.

FUEL: *Wood.*—Though a great variety of substances have been used at various times, and in different places, as fuel, those almost universally employed are reducible to wood, peat, and coal, with their modifications, charcoal and coke. Wood, on account of its very general diffusion, and its convenience as a heat-giving material, has been always used for the production of artificial heat; and, for some purposes, it continues to be more suitable than anything else: thus its freedom from sulphur, etc., confers upon it superior excellence in the reduction and manufacture of iron. In *new* countries wood is usually, at first, cheap and abundant, from the necessity of clearing the forest; but its price is soon augmented, since the labour required to fell it is expensive, and the difficulty of transportation is often

so great, that it is burned or allowed to rot after having been cut down. Hence, the writer has seen in Canada localities surrounded by forests, and yet supplied with coal, brought from the United States by lake and rail, almost as economically, as with wood. In *old* countries, from the great value of land, and often from the abundance of coal, the supply of wood is very limited. But it might be grown for constructive and engineering purposes, very abundantly in Great Britain and still more so in Ireland, if the vast extent of mountain and other unproductive land were devoted to it. Not only would a large amount of profit be thus secured to the owners, but the appearance of the country would be improved, and (on account of the changes produced in the atmosphere by growing plants) its healthfulness would be augmented. The value of wood, where nothing else can be profitably cultivated, and its effect in beautifying wild scenery, are not as much remembered as they should be. On the continent of Europe, where it is grown in large quantities, the most romantic views derive their interest from picturesque and extensive forests.

Many and valuable experiments have been made on the heating powers of the various kinds of fuel; but they can be looked upon merely as approximations, since not only the various species, but the various specimens of the same species, differ greatly from each other. The heat-giving power of fuel depends on the nature and proportions of its constituents. Though it is intimately connected with the quantity of oxygen which enters into combination during combustion, it would be incorrect to assert that a pound of that supporter will cause the same amount of heat to be evolved, whatever the substance with which it unites; for something depends also on the nature of the combustible, since the quantities of heat obtained from different subtances, with an equal absorption of oxygen, are not the same. Thus, hydrogen, during combustion, gives out four times as much heat as an equal weight of carbon, though it unites with only three times as much oxygen; and fourteen times as much heat as an equal weight of sulphur, though it unites with only eight times as much oxygen. Wood, and other kinds of fuel, owe their heating capabilities to carbon, or to carbon and hydrogen. But the highest duty of a pound of carbon may be considered as about fifteen pounds of water evaporated, after having been raised to a temperature of 212°; and of a pound of hydrogen, as about sixty-two and a half pounds. These quantities suppose that all the heat is carried off by the waste steam; but, if the heat of the latter is utilized in any way, the theoretical amount of duty is increased. Any oxygen present in fuel diminishes the effect derived from the hydrogen, since the heat obtained from it is lessened by any portion of it being

already in combination with the supporter. One pound of ordinary wood, in a proper condition for burning, will raise about twenty-six pounds of water from 0° to 212°, or will evaporate four and three-quarter pounds of boiling water; but much depends on its hygrometric state.

Peat.—From the comparatively limited supply of this substance, and other circumstances, it might almost be neglected in treating of fuels. Its efficiency depends, in a great degree, on its compactness and its freedom from earthy matters. The former is sometimes artificially increased by pressure: but its elasticity is an obstacle to its compression, and the cost of condensing it is considerable; if, however, its density is sufficient, it is applicable to many important processes. The qualities of peat are so variable, that while one pound of some kinds will raise sixty pounds of water from the freezing to the boiling point, one pound of other kinds will not raise twenty pounds of water through the same number of degrees; and its calorific power when dry is only about half that of the same weight of coal. But much depends on the locality in which it is obtained: good Irish peat is twice as effective as the best kinds found in France.

Coal.—Notwithstanding the enormous quantities of coal with which this country is so happily furnished, the period at which it superseded wood is not very remote. It is universally admitted to be of vegetable origin, but the forms of vegetation of which it consists are so imperfectly known, that they afford little information as to the state of the earth at the time they were produced. In peat, the vegetable matter exists in various stages of decomposition: lignite is evidently the carbonaceous residue of forest-trees; brown coal is vegetable matter in a state intermediate between that of wood and bituminous coal; semi-bituminous, or "steam coal," is that which is in a state intermediate between bituminous coal and anthracite; and the latter is bituminous coal from which the gaseous constituents have been expelled, most probably by heat, so that many specimens of it contain only a small amount of oxygen, and little or no hydrogen. The following are, on an average, the chief constituents of the substances just mentioned:—

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Beech	48·89	6·07	43·11	0·93
Oak	50·64	6·03	42·05	1·28
Lignite	62·80	5·03	23·27	0·00
Brown Coal	69·74	7·07	9·24	0·14
Bituminous Coal	81·60	5·27	7·91	0·39
Steam Coal	85·57	4·64	2·18	1·03
Anthracite	89·21	2·48	0·20	0·17

The chief heat-giving constituent of coal is its carbon, which, in the bituminous kinds, varies from sixty-five to ninety-five per cent. One pound of good coal will raise about sixty pounds of water from the freezing to the boiling point; but small coal of the same kind will raise only about forty-five pounds through the same number of degrees. Watt was able, on an average, to evaporate seven and a-half pounds of water with one pound of coal; and with ordinary boilers, there has not been much change in this respect since his time. A cylindrical boiler will evaporate only seven pounds; but a "Cornish" boiler, ten and a-quarter pounds; and a locomotive boiler, with one pound of coke, from eight to nine and a-half pounds. If the full effect of one pound of coal were obtained, it should evaporate about sixteen pounds; but a large portion of the heat usually passes off into the chimney.

Charcoal.—As might be expected, equal weights of dry charcoal afford equal amounts of heat, at whatever temperature it is burned, provided it is changed into carbonic acid by union with a sufficient amount of oxygen. One pound of wood charcoal will raise about seventy pounds of water from zero to the boiling-point: and a cubic foot of charcoal from soft wood weighs about eight and a-half pounds, but from hard wood about twelve and a-half. One pound of peat charcoal will raise upwards of sixty pounds of water from zero to the boiling-point.

Coke.—This substance is of very different qualities, according to the coal from which it is made, and the mode of its manufacture; oven coke is far the best, gas coke being mere cinder. The density of coke, its most important quality, depends on the quantity manufactured at once—since, the greater this is, the greater the pressure, and therefore the greater the compactness of the result; on the temperature at which it is manufactured—since if this is high enough, the bicarburetted hydrogen evolved will deposit half its carbon on the coke; and on the time during which it is kept in the oven—since continued heat causes it to contract. One pound of good coke will raise sixty-five pounds of water from zero to the boiling-point, while one pound of the coal from which it is made will raise only sixty pounds through the same number of degrees.

Heat. *Production of heat from fuel.*—Open fire-places, or stoves, are most usually employed for the purpose of heating apartments; the former are more agreeable, the latter more economical. When an open fire-place is properly constructed, the effect obtainable from it is sufficient, under ordinary circumstances: but, in cold regions, such as a large portion of North America, it would be very ineffective for heating or culinary processes; and hence the almost exclusive use of stoves through so great an extent of the New World. They are generally

placed far out in the apartments, and their flues are so arranged as to traverse a considerable space before entering the chimney, that the products of combustion may part with as much heat as possible previous to their escape; for, after the gaseous current has ceased to be applied to heating purposes, the heat it contains is totally lost. The whole heating power of the fuel, therefore, is not obtained, unless the temperature of its gaseous products is lowered to that of the atmosphere; this is impossible when it is burned in the ordinary way, but the nearer we approximate to it the better. The heating of rooms, in very cold countries, by stoves, is not only economical and convenient, but productive of a pleasing temperature with great ease when their management is understood. All disagreeable smell, and other inconveniences—unless the heat is allowed to become immoderate—are prevented, by placing on each stove a vessel of water for evaporation. Stoves are, however, more suited to the use of wood than of coal: the combustion of the latter is not so easily regulated, and the soot which it produces is more troublesome, though not so inflammable. When reasonable care is taken, they are not found very liable to cause accidents by fire; nor would insurance companies, in the countries where they are used, consider their absence an additional security. For culinary purposes, at least with wood, they are extremely effective, convenient, and economical: and, however employed, they consume much less fuel, for a given heating power, than an open fire-place. In the application of heat to the objects of the manufacturer, all the discoveries which science has made with regard to combustion have been brought into operation. The conditions required for perfect combustion are few and simple, but they are of the highest importance: a proper supply of the supporter must be provided, and it must be mixed with the combustible at a sufficiently high temperature. If either of these is imperfectly fulfilled, a waste of fuel and the want of a proper temperature will be the inevitable consequences.

It will be useful to notice briefly the chief sources of a waste of heat during combustion. Of these, not the least common is the presence of *hygrometric water* in the fuel. This must cause a loss of heat, since, as it will certainly be evaporated, its amount is to be deducted from that of the water which otherwise would be converted into steam; or the heat it absorbs must be considered as diminishing that which should be applied to the object in view. Newly-felled wood often contains fifty per cent. of water; and so much of the heat given off by the remaining fifty per cent. is consumed in evaporating it, that scarcely any useful heat remains. After twelve months, wood may contain twenty-five per cent. water: and, if it is kept in a dry place, ten per cent, which, if expelled artificially, will be re-absorbed from

the atmosphere. Beech contains the least, and fir the most moisture. The peat of commerce frequently contains twenty-five per cent. water, and when carefully dried, at least ten per cent. Coal usually contains one or two per cent., but very much more if exposed to the atmosphere and rain, particularly when it is in dust or small pieces. By exposure to the air, charcoal absorbs at least ten per cent. water, which causes flame during its combustion, the water being decomposed, and carburetted hydrogen formed. In wet weather coke will absorb seven per cent. of water. It is clear that, in purchasing fuel by weight, its hygrometric water may seriously affect the quantity in reality obtained, and therefore its commercial value.

Primage and *leakage* cause heat to be wasted. The former, which consists in water being mechanically suspended in the steam—not to speak of its other inconveniences—involves a loss of the heat expended in raising such water from the temperature of the feed to that of the issuing steam. The less pure the water in the boiler, on account of mud or greasy matter, the more rapid the evaporation, the greater the loss from this source: and hence the primage is greater with locomotive than with fixed boilers. Keeping the boiler clean, and allowing the steam a sufficient space for deposition of the water, reduce the waste, from this cause, almost to nothing. Leakage of water or steam leads to a waste of all the heat carried off by the water or steam which escapes.

The heat required to produce a *draught* in the chimney is another source of loss, the amount of which depends on the quantity of gaseous matter passing off, and the temperature at which it is emitted. The minimum of quantity is the transmission of just so much air through the furnace as will burn the fuel; and the minimum of temperature is that which exceeds, by only a few degrees, the temperature of the water, which is being converted into steam of the required pressure. The temperature at which the products of combustion cease to act on the boiler, or other body to be heated, is a matter of considerable importance: and any loss arising from it is dependent on the elevation of temperature of the waste products, and on their weight and specific heat. It is not unusual for these to pass off at a temperature of 600°; and this, with twice as much draught as is necessary, would cause a loss of nearly twenty-seven per cent. of the whole heat. A diminished draught, by raising the temperature of the products of combustion, increases the heat of the escape current also; and therefore a diminution of the draught to a nearer correspondence with what theoretically may be required, does not economize the heat as much as might at first be supposed. But the loss from this latter cause does not counterbalance the advantage, since the higher the temperature

of a body, the more capable it is of heating another; the capacity, therefore, of that other for heat is practically increased. When the capacity of a boiler for absorbing heat is augmented, its size may be diminished; and hence, a proper draught will render a smaller boiler sufficient, or will leave more of a larger to take up the residue of the heat after its first violence is expended. For, one square foot of boiling-heating surface, with a suitable draught, will produce as much effect as five square feet of equally efficient surface, when the draught is four times what it should be. The difference between the heating effect of a well-regulated and an excessive draught is very great; for, while the one will produce a temperature of 3000° and upwards, the other may not afford one of 2000°: a little seeming waste, in producing the former is, therefore, real economy. The draught may, however, be so violent, as not to allow time for the heat to be imparted to the boiler; or it may be so languid as, in certain cases, to be attended with inconvenience, and even danger. Thus, if the temperature of a chimney or flue is not sufficiently high, the carbonic acid which is formed by combustion, and which is one and a-half times as heavy as common air, will flow backwards. By a certain arrangement of an American stove, a small quantity of wood may be kept smouldering for the whole night: this is a convenient way of maintaining a moderate temperature without any trouble or attendance; but in sleeping apartments it is not unaccompanied by danger.

Conduction of heat, from the boiler to the surrounding solids, and *radiation* from its surface, are also causes of heat being wasted. Locomotive boilers are particularly subject to these inconveniences; and the evil is much greater when the cylinders are outside. The excellence of what is termed a "Cornish" boiler, consists, almost exclusively, in the care with which it is insulated by felt, brick, and other non-conductors of heat.

Finally, heat is lost by the passing off of *uncombined fuel*. This may occur mechanically, from fuel being dropped among the ashes, which must happen if the coal is small, or if the distance between the bars is too great: they must not, however, be so close as to prevent a proper supply of air. Some kinds of coal break down with great rapidity during transmission, and even in the very steamers in which they are used; and some, from the water which is chemically combined with them, split up and fall to powder when heated. Waste from uncombined fuel may occur also from the production of *smoke*; that is, from incomplete combustion. The prevention of visible smoke has for a long time occupied the attention of men of science. It is indispensable to the economical application of fuel; because smoke consists of carbon and other matters,

which are a most effective portion of the combustible, and which, if allowed to escape into the atmosphere, are totally wasted. When the combustion is imperfect soot will be formed with a part of the carbon, and, instead of carbonic acid, carbonic oxide may be evolved. The hydrogen also, in place of being burned, may form hydrocarbons, such as carry vapours, and pass off; or it may escape without having entered into any combination. In all these cases a large amount of the heat which should be derived from the fuel is lost. Smoke is not only a loss to the manufacturer, but an injury and an annoyance to the neighbourhood, by rendering it less healthy and less agreeable; hence, the manufacturer is obliged, by Act of Parliament, to "burn his smoke." Burning it, is enough to prevent inconvenience to others; but preventing it, would be more advantageous to himself, since carbonaceous matters combine with oxygen much more readily when they are in the *nascent state*. Smoke will certainly be consumed, if its constituents are mixed with oxygen in proper quantities, and at a proper temperature. Atmospheric air contains, by weight, twenty-three per cent. oxygen; and sixty cubic feet may be considered to afford one pound of it. Hydrogen requires for combustion eight times its weight of oxygen; and carbon two and two-third times its weight. One pound of hydrogen, therefore, absorbs the oxygen of four hundred and eighty cubic feet of atmospheric air; and one pound of carbon, that of one hundred and sixty cubic feet. The carbon is believed to be capable of giving to the products of combustion a temperature of 4400° Fahr. if its combustion is perfect, and some of the heat is not carried away by excessive draught.

Since the compounds of carbon and hydrogen are found to afford the same amount of heat as their constituents, it is not necessary, in examining the effects which ought to be expected from hydrocarbons, to consider each of them separately; it is enough if the nature and amount of the elements of which their aggregates consists, are ascertained. Compounds of carbon and hydrogen are usually decomposed by the high temperature, before they are burned; then, hydrogen having the greatest affinity for oxygen, first combines with it, liberating the carbon; the carbon, if there is enough of oxygen, with a sufficiently high temperature, afterwards forms carbonic acid; but if there is a deficient supply of oxygen, the carbonic acid takes up another atom of carbon, becoming carbonic oxide: in which case as much heat per pound of carbon, is carried off as would raise 10,100 lbs. of water one degree Fahr. The blue flame which surrounds the opening, and plays over the fuel, when the door of a locomotive furnace is opened, arises from the extra supply of air changing what was passing off as carbonic oxide into car-

bonic acid; and the flame seen at the top of a chimney is due to the same cause. Perforating the furnace door partially prevents this waste. Since the elements of coal, coke, etc., exist in the solid form, in changing to the gaseous state they absorb a large amount of the heat derived from previous combustion; and the gaseous products of combustion carry off so much heat, that it is believed their volatilization consumes as much of it as is given out by their combustion: hence, there is reason to doubt that the effect of any coal containing hydrogen is greater than that of its carbon; and it has been found that coal containing the smallest quantity of gases, is, practically, the most effective as a heat-producer. When coal contains hydrogen, the resulting water forms double its volume of steam.

We may err by having too great as well as too small a supply of air. If the latter is in excess, the heat being dispersed through a greater quantity of matter, the temperature obtained is less than it should be. When twice the proper quantity of air is admitted, the temperature of the products of combustion will be only about 2300°, or little more than half what might be expected; yet five, and even ten times the proper amount is often supplied to the fuel. We must not, however, confine ourselves to the theoretical quantity, since only about two-thirds of what is sent into the furnace comes in contact with the combustibles.

Various means have been devised for the consumption of smoke. It is not enough to increase the height of the chimney: this would indeed augment the draught, but would produce little other effect than the diffusion of the nuisance over a wider space. Among the most effective means that have been employed, is mixing air with the smoke. When fuel is put on the *dead plate*, so that it may be coked, and its volatile constituents mixed with air may pass over the fuel which is at a high temperature, air is required *above* the fuel. If this is cold, on account of being drawn directly from the atmosphere, not only is the bottom of the boiler lowered in temperature, and the generation of steam in consequence diminished, but the smoke is not all destroyed. It has been attempted to obviate these inconveniences by supplying the required air through tubes passing down within the chimney; but this, by cooling the contents of the latter, diminishes the draught, and thus affects the supply of the supporter of combustion. When, as with coke, or cinders of any kind, the combustion is confined to the fuel on the grate, air is not required above; yet such is the neglect, not unfrequently observed, that the same draught may be sometimes found with every kind and quantity of fuel.

When the waste steam was first thrown into the chimney of locomotives, it was found that the draught was enormously

increased. This principle, in a modified form, has been applied to the consumption of smoke: for which purpose a small quantity of steam is thrown into the forepart of the furnace, above the fuel, by a fan-shaped distributor, having a few small apertures; and the instant the steam is turned on through the flame and smoke, the latter disappears. The cause of this extraordinary effect is not certainly known. Some consider that the steam merely carries the air mechanically to the fuel; others, that the steam is decomposed by the carbonaceous matter of the smoke at a high temperature, carbonic oxide and hydrogen being produced; and that the combustion of these augments the amount of heat evolved. The latter supposition is apparently confirmed, by the fact that more water is sometimes evaporated than can well be ascribed to the fuel: in which case, it would seem reasonable to attribute some of the effect to combustion of the hydrogen; but whatever heat is given out by the burning hydrogen must have been first obtained from the fuel itself, since exactly the same amount of heat is required to decompose water, as is afterwards evolved during the recomposition of its elements. The steam increases the draught to such a degree, that its force must be diminished by side openings in the chimney, or other means; and hence, supplying air for combustion by tubes passing down through the chimney ceases to be injurious; and the chimney may be made smaller and lower. Since with this contrivance no air passes through the ash-pit, combustion takes place altogether on the surface of the fuel; and the absence of smoke causes the heat to be radiated more directly, and, therefore, more effectually, on the bottom of the boiler.

We have now briefly alluded to the best modes of using the more ordinary kinds of fuel; and, from the great difference between the amount of heat obtained in practice and that which theory would lead us to expect, it can easily be imagined how much yet remains to be done in this department of practical science. The separate condensation of steam, invented by Watt, and the application of the principle of expansion, by Woolf and Hornblower, greatly augmented the dynamical value of fuel; and yet the mechanical effect obtained from even the best condensing expansive engine is many times less than it would be if, according to the received "mechanical equivalent of heat," the whole heat were changed into work. The locomotive, from its peculiar position, is, perhaps, least favourably circumstanced, so far as relates to the economy of fuel; yet, with all the sources of waste to which it is exposed, it will do as much work with one pound of coke as a good non-expansive condensing engine with a pound of coal, and more than twice as much as a good high-pressure stationary engine with the

same. Theoretical and practical results will, it is true, never entirely correspond, but they should be much more nearly alike than they ever yet have been. Whatever improvements have at any time been effected in the economy of fuel, have originated in a careful and rational application of the physical laws which relate to combustion, and of those on which the doctrine of heat is founded. Apparent trifles, such, for instance, as insulation of the boiler by non-conductors of heat, accommodation of the draught to the nature and quantity of the fuel, etc., have been the cause of very important saving on the item of fuel; and whatever good shall be hereafter effected in the same direction, will be due to a like judicious application of the practical knowledge with which experience and research shall have furnished us.

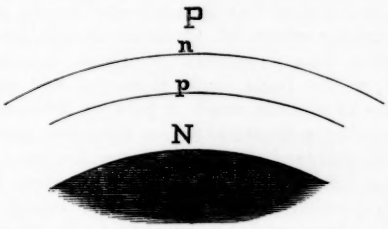
QUETELET ON THE ELECTRICITY OF THE AIR.

In his important work, *Sur la Physique du Globe*, M. Quetelet gives a voluminous account of the electrical observations made under his superintendence at Brussels, and devotes one section to an explanation of the distribution of the electricity of the air, which cannot fail to interest our readers, and which we therefore present to them in a condensed form.

M. Quetelet remarks, that were it not for the existence of other bodies in celestial space, the terrestrial atmosphere would scarcely experience any electrical changes. He further tells us that the sun must be regarded as the chief exciting and disturbing cause. He regards our atmosphere as divided into two layers; the upper one, *n.p.*, "nearly immoveable in all its parts, the lower one, *p.n.*, constantly traversed and stirred up by winds." The upper layer he considers is also divided into two portions: the one negative, *n.*, equilibrates the positive electricity, P., of the sun, and of the surrounding space;* and the other positive, *p.*, acts through the lower stratum of air, and equilibrates the negative electricity of the earth, N. The positive and negative electricities of the upper regions of the atmosphere are kept apart by the extreme dryness which must prevail

† M. Quetelet adds in a note, "If it is objected that the electricity of the sun traverses the void without resistance, and that its fluid ought to unite with the fluid of the opposite nature which we suppose to exist in the exterior layer of the atmosphere, we might without difficulty admit this hypothesis, and our explanation would be simplified. There would, in fact, remain only the positive electricity below the superior envelope of our atmosphere, which would paralyze on one side the negative electricity of the sun, and on the other would act through the inferior envelope and paralyze the negative electricity on the surface of the globe. We must then admit that the electricity of the sun and the earth are of the same kind.

there. In the lower stratum absolute dryness does not exist. It is more or less moist, constantly disturbed, and traversed, although with considerable difficulty, by the positive electricity which can at times unite with the opposite electricity of the earth; but these never exist in intimate connection. The action is like that of two conductors charged with opposite electricities and placed at a distance: "the opposite fluids tend to unite through the more or less moist air that is interposed, but their charges remain the same. If the losses are constantly renewed, the positive fluid of the upper layer gives rise to all the electrical phenomena that we observe upon our globe.



Being partially retained by the dryness and relative immobility of the stratum in which it finds itself, it operates through the lower stratum, which is always agitated and always more or less humid, and partially paralyzes the electricity indicated by our instruments on the surface of the globe."

In our northern hemisphere, the electricity is stronger in winter than in summer. The layer of the atmosphere that is constantly disturbed is not so thick at this season, and thus we are closer to the upper layer. In the course of a year, this augmentation of electricity and diminution of height becomes very apparent; between June and January, or December, the variation is as much as 1 to 10. Nor is the diurnal variation less noticeable, "the electricity becomes stronger towards the approach of night, and its minimum occurs a little after the hours of strongest heat during the day. It is towards three o'clock P.M. in the summer time, that the electrified layer which acts upon our instruments appears to be furthest removed from the earth." It should also be remembered that as heat augments, and the air becomes drier, its conducting power is diminished. During the night the solar action is insensible, and the variation is much less, and that which occurs appears to be the result of changes in the opposite atmosphere.

M. Quetelet observes that we have no precise ideas of the *absolute force of electricity*, and that we do not know whether

its intensity is greater in the north than in the south, although if the upper stratum of the air is not so high, the electricity must be stronger, as seems to be shown by the auroras. "The earth is generally regarded as solid throughout all its extent, although many physicists consider that it is only solid in its exterior portion. They say, and as we think with reason, that the interior portion, in a state of greater or less fluidity, may have its own movements, which may occasion magnetic variations, and also the electric variations that are intimately connected with them."

The great laws of the distribution of atmospheric electricity are often masked by secondary causes. Thus, especially during the summer, we notice the formation of strata of clouds carrying an electricity which M. Quetelet denominates *accidental*, and which gives rise to storms. "These clouds may be the origin of hail, which finds itself attracted and repelled by the upper stratum of the air, until it falls by force of gravity," or there may be a direct electrical action upon the earth in the shape of storms. Negative electricity is more frequent in the atmosphere during the summer, the space between the earth and the stationary portion of the atmosphere being then greater, and also being drier and better able to accommodate clouds which assume "a supplementary electricity." The tranquil passage of electricity towards the earth is more frequent in winter, but in the summer, by reason of the greater dryness, it is less continuous and more violent. Thunder-storms are more common in summer than in winter, but those of the latter season are often extremely dangerous. One, for example, in the winter of 1860, struck twenty clock towers within the limits of Belgium, and in the course of a few hours; and in the night of April 14th, 1718, twenty-four towers were struck in France, along the coasts of Brittany. Summer storms are usually less destructive on the surface of the earth, and their action limited to a smaller space. Winter storms act over a wider range.

M. Quetelet gives numerous details of the great storm of the 19th February, 1860, to which allusion has just been made, and which surpassed in violence any ever known to have occurred in Belgium. It began on the evening of the Sunday in question, and followed the route usually taken by such scourges in that country. About seven o'clock it burst over Rolleghem and Courtroy; an hour afterwards it reached Ghent, Brussels, and the neighbourhood of Antwerp; and by nine it was at Liege, carrying devastation as it went, and increasing in force. Hail, rain, and snow fell at various places during its passage, several of the churches upon which the lightning fell were set on fire; the wind was tempestuous, and the thunder-peals extremely loud. The barometer was strongly depressed,

and the thermometer experienced considerable oscillations. M. Duprez, commenting on this alarming visitation, states that fourteen out of twenty-two cases of buildings being struck resulted in fires, and that the only edifice which was provided with a lightning-conductor suffered no damage. M. Quetelet adds that, in his statistics of buildings or vessels struck by lightning, he found that out of a hundred and sixty-eight cases in which lightning-conductors had been struck, only twenty-seven, by reason of grave defects in their formation, had failed to exercise a preservative power.

The average annual allowance of thunder-storms for Belgium is fifteen or sixteen, and they are twenty-one times more numerous in summer than in winter. The annual number for a particular locality will vary considerably, being four times as many in some years as in others, while fifteen or twenty leagues away, the average has not been changed. In our northern countries winter storms, while the sun is below the equator, are usually formed between the clouds and the earth; those in summer, when the sun is above the equator, are formed in a higher region between the clouds and the stationary layer of the atmosphere, and they have less tendency to strike elevated objects. Their region of action is often very limited, extending over only a few leagues. The velocity of the movement of thunder-storms equals that of the most rapid winds.

THE SEA LAMPREY

(*Petromyzon marinus*).

BY JONATHAN COUCH, F.L.S.

(*With a Coloured Plate.*)

THE large Sea Lamprey is one of the most remarkable of fishes, both as regards its organization and habits; and as such, without appearing to have done so, it has obtained special notice, as well among the ancients as moderns. But as actual and close observance of the forms of the inhabitants of the ocean for the purpose of scientific distinction was not much practised in ancient times, some curious mistakes were committed about it by writers of remote date; most of whom, at least those whose works have come down to us, must have written from the imperfect information which they had gathered from common sources; and in doing this they appear to have felt the greater readiness to receive it in the proportion that it was strange and mysterious.

It was commonly believed that there was a fish called the

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Naucrates, Remora, or Echeneis, which, when it pleased, laid hold of a ship, and by means of a magical power which it possessed, and which was inscrutable by human intellect, and therefore above being reasoned on, it was able to arrest its progress in the midst of its most onward course, and thus fix it stationary in the middle of the ocean. Ordinary observation had shown that the lamprey was in the habit of laying hold of a ship so firmly as not to be easily separated from it; and without attending to the difference in the mode of acting, by what seemed a natural process of reasoning they drew the conclusion that where the action was so much alike the fishes themselves must be the same. These dissimilar fishes, therefore, the Remora and Lamprey, became confounded together, and that, indeed, to such an extent, that when taken in the sea there is reason to believe that the lamprey lost, if it ever possessed, a specific name; which circumstance will help to explain how it happens that there does not appear to be any direct mention of it in the natural history of Pliny, although the fish itself is common in the Tiber. The fact, however, of the knowledge of this fish by the ancients, with the uncertainty arising from confounding it with the Remora, Naucrates, or Echeneis, appears with little doubt, from the description which Oppian gives of the last named species. His reference to its teeth is decisive in this respect, for these organs in the Naucrates are scarcely perceptible, and certainly are not employed in the action which rendered this fish so famous:—

> "Slender his shape, his length a cubit ends;
> No beauteous spot the gloomy race commends;
> An eel-like clinging kind, of dusky looks;
> His jaws display tenacious rows of hooks.
> But in strange power the puny fish excels,
> Beyond the boasted art of magic spells.—
> The sucking fish beneath with secret chains
> Clung to the keel the swiftest ship detains."

When, however, the lamprey had come under the notice of another class of observers in its yearly migration into fresh water, its marine practices were forgotten or unknown, and it assumed a name according to the likeness it was supposed to bear to some more familiarly-known fish. Ray, in his little work, *Nomenclator Classicus*, very properly finds fault with those English writers, especially the poets, who translated the Latin name of the fish Muræna, by the English term Lamprey, which John Jones, the translator of Oppian, always does, although these fishes are different in every respect. But we have already remarked that scientific differences were little thought of by the generality of the ancients. It was sufficient for them that there was some, although a distant resemblance; and in

the present instance of the Muræna this resemblance, as regarded the shape, was thought sufficiently close to warrant the transfer, with some little qualification, of the name of one of these fishes to the other. Rondeletius is sufficient authority for saying, that the sea lamprey was sometimes called Muræna simply, or *Muræna fluviatilis*, the River Muræna, which he distinguishes by an anatomical difference in the head from the Muræna of the sea; and he thinks the comparison of one with the other not amiss. There is much probability also in the opinion that it is the lamprey which is mentioned by Ausonius, under the name of Mustellax, although Cuvier has said that the Burbolt is the species intended by this Roman poet. The important fact, however, of its migrating habit from salt water, which he refers to, and which is not a character of the Burbolt, and the description of its colour, appear sufficient to decide the question:—

> "All through the ponds of Ister's double name,
> Frothing the surface, the Mustella came;
> Watched by observant eyes it holds its way,
> And safely shelters in our favoured bay;
> Bringing new riches to the wide Moselle;
> And its bright beauties who can paint or tell?
> On breadth of heavenly blue are dots of black,
> Each circled yellow through the luscious track
> Along the slippery surface of its back.
> From head to vent it suits the nicest taste,
> But all behind is dry, and thrown to waste."
>
> *Ausonius's Moselle.*

The fact that the Burbolt is still called Motella in some parts of France will weigh but little when we call to mind how common it is for different sorts of fishes to bear the same name, as also that the same fish is known by several names in different parts of the same country.

This species of lamprey is often taken in the sea, but always under peculiar circumstances, which have reference to remarkable instinctive habits; and these, again, are worthy of notice as offering explanation of the use of the curious structure of its mouth, and of the organization which serves it for the purpose of breathing. This remarkable structure we shall by and by describe, but at present it is sufficient to say, that the mouth, when open, forms an expanded disk, round the deepest portion of which there is an arrangement of rasping teeth; and these the fish has the power, however difficult it may appear, of bringing into contact with any surface on which it chooses to lay hold. By an exhausting action through which the air and water are removed, a vacuum is produced; and thus the fish becomes fixed without any further exercise of muscular action. The bottom of a ship or boat is frequently the object to which it attaches itself, and it becomes a question what is the inten-

tion kept in view in thus affixing itself; which it does so firmly, indeed, that the utmost strength of a man is often unequal to the task of removing it. The object may be no greater than to relieve itself from further exertion in swimming, and, as in the instance of the true Remora, to be conveyed to a longer distance with the least expenditure of strength. It may also be with the hope of feeding on the flesh of an animal, for which it has mistaken the ship, according to what we know of its propensities under other circumstances; but it is affirmed by Rondeletius that it is also with the intention of devouring the pitch with which the ship has been *payed*, or coated, and for which it has been supposed to feel an appetite. Such was the opinion, at least, formerly entertained by the fishermen of Marseilles; and strange as it may appear, a similar opinion has been expressed in England by a witness in an inquiry by a parliamentary commission on the salmon fisheries, in the year 1861. It was then shown that under peculiar circumstances, not only salmon, but lampreys also, tasted strongly of tar. The witness said, "We asked the fishermen about it, and they told us that there was a little ripple of tar coming down into the Severn, and that must have been the reason (with the salmon). We were rather angry with the fishermen, and then thought they had put these salmon into a boat where tar had been emptied; but they said no, the tar in the river must have been the reason. We had two lampreys returned that tasted very badly of tar; we found out the reason of that. Lampreys have mouths like suckers, and live by suction; and they will suck tightly to anything. The boats had been newly tarred, and these lampreys sucked on to the boat, and from that they were all tar. I am quite certain that the lampreys did not get the tar out of the water, but out of the boat. These tarred fish were confined to one year."

It is not so certain, however, that the vegetable tar attracts these fish as that coal tar drives them away; and accordingly it has been noticed that since the sea-going boats have employed the latter no lampreys have laid hold upon them.

But there is another use to which the mouth is applied, concerning which no doubt can exist, and by which the singular situation and armature of the teeth are to be explained. The whole of the interior arch of the mouth is studded with rows of teeth, each one of which, on a broad base, is furnished with one or two apparently reversed points; and these teeth which are most remote and concealed are larger than others, and more effectually crowded with these points. For simply biting they are useless; but when the breadth of the mouth is brought into contact with the surface of a fish on which the lamprey has laid hold, by producing a vacuum these roughly-pointed teeth

are brought forward so as to be able to act on it by a circular motion; and a limited space of the captive prey is thus rasped into a pulp and swallowed, until a hole is made which may perhaps penetrate to the bones, and from the torture of which the most strenuous exertion of the victim cannot deliver it. The most active fishes are subject to this infliction, and on none have I found it more frequent than on the mackerel, although the gurnard, coal-fish (*Rauning Pollack*), cod, and haddock, have been also the subjects of attack. It might be supposed that death would be the inevitable fate of fishes which have been thus dealt with; but I have seen some that have borne the mark of having been thus fed on, which after having perhaps satisfied the appetite of their foe have survived to have the wound healed, although not without an enduring mark. In repeated instances a lamprey which did not exceed six or seven inches in length has been caught while still adhering firmly to the body of a mackerel; a circumstance which happens most frequently in the spring of the year. It is in the spring, and with us about April and May, that the lamprey is ready to deposit its spawn, for which purpose it seeks the fresh water of the deepest of our rivers. I have had it brought to me from the sea with the roe enlarged on the 11th of April, and also in the middle of May; but in Holland, Ruysch says it is so early as February, and in Scotland Sir William Jardine assigns it to June, and thenceforward so late as to the end of August. It is at this its first entry into the rivers that the fishery is entered upon for taking it. The Severn has long been celebrated for this fishery, and for the excellency of the lampreys taken in it. Indeed, it is not known that this fish is much sought after in any other river; and even there so fluctuating is the taste of epicurism, that within a few years the sale of it has much declined. They are fished for mostly in the night, and from thirty to forty are regarded as a successful adventure, at the price of a shilling to eighteenpence for each fish. But it was held of higher value in remote times, and an often quoted instance in English History is a proof that it was once deemed a favourite dish at the table of a king. The death of Henry I. was caused by his having indulged too freely in a dish of potted lampreys. The value set on the lamprey is also shown by the fact that it was thought a not unfitting present to be sent by the king to a subject of high rank. King John sent one lamprey to the Earl

The Mouth of the Petromyzon marinus.

of Chester, and the honour of the gift was acknowledged by the present of a good palfrey in return. It was an old custom for the Corporation of the City of Gloucester to present to the reigning sovereign a pie of lampreys yearly, but it appears that this custom has ceased to exist; an end probably having been put to it on the occasion of the passing of the Reform Bill. In the last century also a lamprey-pie was sent by the Corporation of the same city to the Prince of Wales. As this kind of lamprey enters rivers for the purpose of spawning in the spring, so this is also the season of its highest perfection; but immediately after the discharge of the roe, so great a change in this respect takes place, that they are not only weakened and emaciated, but it has been believed they are so far from recovering their former condition that even death is the result. In the sea this fish is said to be worthless for the table. However, that this last supposition is not correct appears from the fact, that while in May, twelve months perhaps from their birth, they are often found not to exceed six or eight inches in length, some examples are met with which measure more than thirty inches, and which therefore we may conclude to have experienced the growths of several seasons, and consequently to have passed through more than one or two of those in which the spawn is deposited.

The mode of proceeding by which a procreant bed is prepared for the reception of this treasure affords an insight into another use to which the sucking faculty of the mouth can be applied. Both sexes unite in preparing the ground; and as in the process of doing this it may happen that stones of comparatively considerable size are in the way, the mouth is a principal instrument employed in the labour of removing them, so that the grains of roe may be covered by only a lighter sand. The mouth is applied to the surface of a stone, and by a strenuous effort it is carried to a distance until every difficulty of this sort is removed out of the way. Soon after spawning the parent fish return to the sea.

This fish inhabits a variety of climates except the very warm; being found in the Mediterranean, where those of the Tiber are said to be of large size; and in the north of Europe, where it is mentioned by Nilsson as common in the Baltic and North Sea. It is said also to be met with in North America. It is retentive of life, and so may be carried alive to a considerable distance if sometimes dipped in water.

The genus *Petromyzon*, to which the lamprey belongs, is distinguished by having the mouth formed of a wide opening without distinct jaws; an aperture on the top of the head which communicates with the gills, the spiracles or outlets of which are seven in number. Pectoral and ventral fins none.

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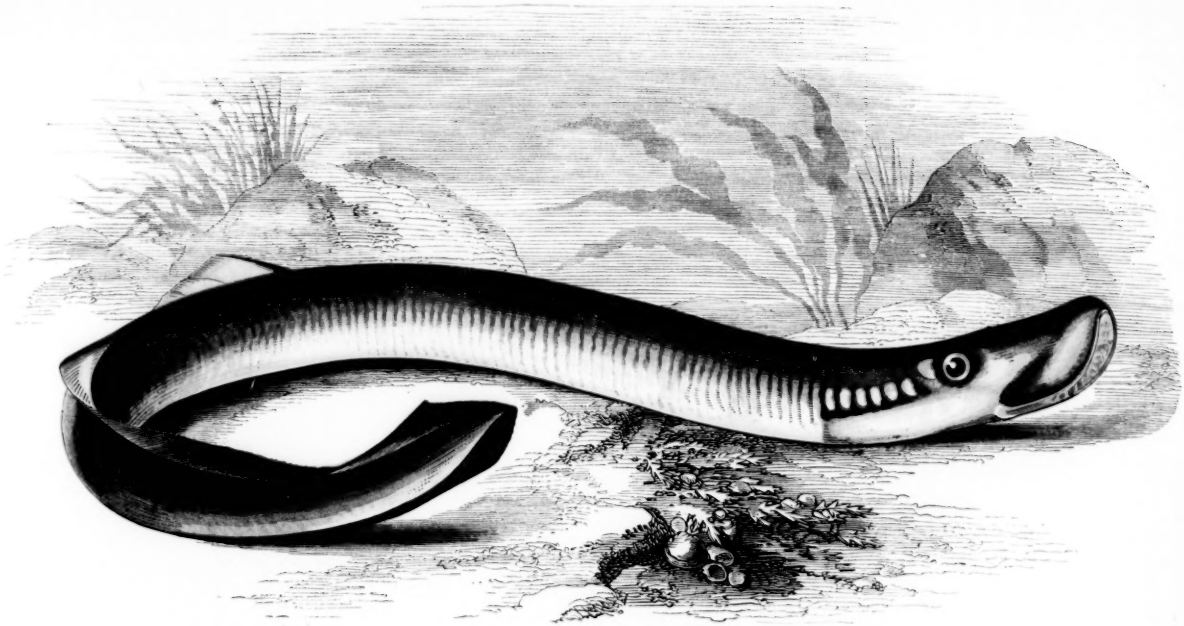

SEA LAMPREY.

The sea lamprey (*Petromyzon marinus*) is specifically distinguished by having the second dorsal fin separate from the tail, although sometimes in only a small degree.

The body is long and round, slightly compressed, but more so near the tail, and thus not unlike an eel. When the mouth is closed, the part before the eyes appears somewhat lengthened; but when open it is circular and terminal, so that the fish appears as if the head had been cut off. The rim of what may be termed the under jaw is a little curved, forming a ridge which is edged with sharp points; on the tongue there is a more solid and firm bed of three teeth, having sharp points; and above, there is an arch of nine bifid teeth, the middle one lower than the others—in all there are ten bifid teeth; the remainder of the mouth is covered with teeth having sharp points, which stand in rows that pass off in curved radii from the throat; the lower ones small: altogether a formidable arrangement. These teeth are deciduous, the new ones thrusting off the old and taking their place. The mode of arrangement is a specific character of this fish, and I have found the renewal occurring in May; but it does not appear to observe a regular recurrence. The mouth is fringed with fibres. Eye moderate, lively; vent far behind. First dorsal fin behind the middle of the body, lower and shorter than the second; the caudal fin separate, and surrounding the tail. The colour is often variegated and beautiful, as it is referred to by Ausonius; but sometimes it is plain and almost uniform; and this difference appears to belong to the district in which the individual is found; but on the whole the tendency is to blue or green, with yellow on the sides and belly. The manner in which the process of breathing is conducted is deserving of notice. Under ordinary circumstances, when the mouth is open, the water probably enters by it and passes out by the openings of the gills; as it does also when the mouth is held above the water, and water is seen to be drawn in by the opening on the head. But on some occasions when wholly immersed it was discharged by that opening as well as by the gills; but it was never seen to enter by the gills of one side, as has been supposed, to be discharged by the orifices on the other side. This family of fishes has usually been arranged with cartilaginous fishes, which certainly is not its place. They bear a closer affinity to the annelid or worm tribe. Professor Owen says that in their fully ossified skeleton there is only one and a-half of earthy salt per cent.; and the remainder is mucus, not gelatine.

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GAUTIER ON NEBULÆ.

THE *Bibliothèque Universelle et Revue Suisse* has an interesting article by Professor Gautier on Nebulæ, of which the following is a condensed account :—

The author begins by stating that his purpose is to give "a slight idea" of a wonderful class of objects which have been specially studied by the two Herschels, Messier, Lord Rosse, Vico, Secchi, Lamont, Lassell, and Bond, and of which fifty-three have been accurately placed in M. Langier's catalogue, published in the *Comptes Rendus* of 12th December, 1853. This list gives the positions of the nebulæ with great nicety, and thus lays a foundation for deciding whether they are really situated beyond the fixed stars that are visible to us.

The Orion nebula formed the subject of a paper presented through M. Struve to the St. Petersburg Academy in 1856, and which detailed the results of four years' investigations, conducted by M. Liapounoff (Director of the Kasan Observatory), with an equatoreal telescope, equal to that of Dorpat, and a meridian circle of Repsold. M. Liapounoff noted down the position of every star he could distinguish in this nebula, and in comparing his accounts with those of Sir J. Herschel and Messrs. Lamont and Bond, M. Struve came to the conclusion that it must be subject to changes of form, and of the relative brightness of its different parts.

At Poulkova M. Otto Struve continued the work of M. Liapounoff, as recorded in the Monthly Notices of the Astronomical Society for 1857. M. Struve pointed out the variable light of divers little stars, and he observed : "The existence of so many variable stars in so small a space of the central part of the most curious nebula in the heavens, naturally induces us to suppose that these phenomena are intimately connected with the mysterious nature of this body. . . . . In admitting that the rapid changes of light observed in these little stars, whether in the region called *Huyghens* or that termed *Subnebulosa*, are connected with the nature of the nebula, we may presume that we should equally observe changes in the appearance of the nebula, and in the distribution of the nebulous matter; but observations of this kind are subject to so many illusions that we cannot be too cautious." Among causes of discrepancy between different observations, he enumerated the power of the telescope, the state of the atmosphere, the eye of the observer, and his experience in producing graphic delineations of this kind of object; which, taken altogether, precluded any certain discovery of changes of a progressive character that might occur in short spaces of time. It is, therefore, towards rapid

changes that attention should be directed, and they can be better noted by attending to certain prominent portions of the nebula than by watching it as a whole. Following this rule, M. Struve thought he detected considerable alterations in a single winter, and he mentioned four parts of the nebula in which they seemed to have occurred. The first is a bay extending from the Strait of Le Gentil in the direction of the trapezium of stars situated towards the middle of the nebula. This bay sometimes appeared to him dark like the strait; at others full of nebulosity, and little inferior in light to the parts surrounding the region of Huyghens. Dr. Lamont was the first to describe this bay, which was not seen by Sir J. Herschel. The second is a nebulous bridge traversing the Great Strait, and exhibiting towards its centre a luminous point. In the winter M. Struve saw it as represented by Herschel and by Liapounoff, with much more concentration of light, but always much more extended than it appeared to these two astronomers, and closely approaching the southern limit of the Great Strait. M. Lamont had only indicated the faintest traces of it, and M. Bond had not seen it at all. The third is a nebulosity surrounding star 75 of Herschel's catalogue, and which appeared to M. Struve subject to great changes of light. The fourth is a sort of narrow channel (*canal étroit*) connecting in a straight line the dark space situated about stars 76, 80, 84 of Herschel's catalogue, with the northern margin of the Great Strait. This channel, not figured by any former observer, was distinctly seen by M. Struve on the 24th March, 1857, but on other occasions he could not discover the least sign of it. He thus arrived at the conclusion that the centre of the Orion nebula is in a state of constant change, but he considered that, except under favourable circumstances, no achromatic telescope of less than ten inches aperture would enable them to be perceived.

In 1861 the Monthly Notice of the Astronomical Society contained a report by Mr. G. Bond, of Harvard College, on the "Spiral Structure of the Great Nebula in Orion." Mr. Bond, senior, in 1848 noticed a disposition in the light of this nebula to radiate from the south side, starting from the vicinity of the trapezium of stars situated towards the middle." Mr. G. Bond began, in 1857, to form a catalogue of stars, comprised within a square of 40 minutes, having θ (theta) in its centre. He selected 121 brilliant stars as points of reference for the smaller stars which were of too feeble light to remain visible when his micrometer threads were illuminated. He placed in his first sketch 262 stars. The form and disposition of the elongated luminous tufts, alternating with darker spaces, proceeding from the neighbourhood of the trapezium, were determined by two independent proceedings, the nebula being

first sketched as a light object on a dark ground, and then as a dark object upon a light ground.

The general aspect of the greater part of the nebula as thus depicted, was that of an assemblage of tufts or curved bunches of luminous matter emanating from the brilliant masses near the trapezium, extending towards the south on each side of an axis, passing by the top of the region of Huyghens, and whose angle of position is nearly 180°. Twenty of these circumvolutions were distinctly traced, while others, producing the same impression, are too faint or too complicated to be described with precision. Thus the nebula of Orion belongs to the spiral class.

Mr. Bond noticed many cases in which masses of nebulous matter were associated with stars, frequently under the form of little tufts extending from the south side. He likewise cites two remarkable instances of a deficit of luminous matter close to tolerably brilliant stars. The first occurs in the trapezium itself, the dark centre of which has been noticed by many observers, and the other belongs to the star ι (iota). Mr. Bond inclined to the idea that there was a physical connection between the stars and the nebulosity. The spiral form accorded with the notion of a stellar arrangement, as shown in a mass of stars, properly so called, in the constellation Hercules, which have evidently a curvilinear disposition.

In 1860, Mr. Norman Pogson observed a change in the nebula or mass of stars in Scorpio (No. 80 in Messier's catalogue). On the 9th May, this nebula had its ordinary aspect, without any stellar appearance, and on the 28th of the same month, he noticed in it a star of 7th or 8th mag., which was also seen on the 21st at Königsberg by MM. Luther and Auwers, and estimated by them as below the 7th mag. On the 10th of June following, under a power of 66, the star appearance was almost invisible, but the nebula glowed with more than ordinary lustre, and with a well-marked central condensation. Mr. Pogson did not attribute this variation to a change in the nebula itself, but thought it singular that a new variable star, the third comprised in the same field of vision, should be found situated exactly in the centre of this nebula.

More recently, M. Chacornac has observed the annular nebula in Lyra with the great Foucault telescope, and he has confirmed its resolution into a mass of minute stars, the most brilliant occupying the extremities of the inner axis. This nebula looked like a hollow cylinder seen in a direction nearly parallel to its axis, with its centre, as described by Lord Rosse, veiled by a curtain of nebulous matter which was transformed into a thin layer of little stars. When all other light was excluded, M. Chacornac found that the scintillation of this multitude of luminous points produced a singular effect of giddiness.

M. Gautier then proceeds to speak of the labours of M. d'Arrest, first with a 4½ inch telescope, at Leipsic, and since then with an 11 inch achromatic at Copenhagen, which has enabled him to discover more than 100 new nebulæ. With regard to variable nebulæ he thinks much caution needed. He confirms Struve's observations on the nebula of Orion, and finds Mr. Hind's little nebula in Taurus to be also variable.* The nebula which Sir J. Herschel thought had disappeared, has been seen by M. Chacornac with the Foucault telescope, and by M. d'Arrest with his great reflector.

Sir J. Herschel, in his great paper on nebulæ (published in *Phil. Trans.*, 1833), remarked that the number of nebulæ physically united, is probably larger in comparison with the total number of nebulæ, than that of double stars when compared with the entire number of known stars; and taking 5′ as the maximum distance of double nebulæ, M. d'Arrest has already arranged fifty under that category, and he estimates that there are two or three hundred of this sort out of about three thousand nebulæ visible in our hemisphere.

M. d'Arrest mentions a triple nebula, but only in one instance has he been able to observe noticeable changes indicating a common revolution. The interesting object has a Right Ascension of 109° 12′, and N. Declination 20° 45′. It is represented by M. Lassell, in the engraving accompanying his memoir, in vol. xxiii. of the Astronomical Society. Its two components are distinct, being only separated by 28″, but they are difficult to see when the micrometer threads are illuminated. A very small star is seen between them, exactly where M. Lassell observed it ten years ago.

Finally, M. d'Arrest reports a small number of instances in which a slight change of distance and position has been noticed after the lapse of a certain time, between particular nebulæ and small adjacent stars.

We may remark that, if it can be shown that two or more nebulæ, each probably a system of thousands of suns arranged in a particular order, and at great distances from each other, really revolve about one another, or about a common centre, not only will some of the grandest views of creation be opened, but fresh speculations will arise concerning the nature of the force by which such mighty movements are compelled.

* See Intellectual Observer, vol. ii., page 310.

M. Auwers has published some observations made by him at Göttingen and Königsberg, to show that the two last variable nebulæ of M. d'Arrest have not really altered in luminosity. With regard to the nebula of Mr. Hind, which is the only one whose periodic variation has been proved, the same astronomer states that he saw it perfectly in March, 1858, but that it was feebler than in 1856. M. Chacornac could not find it in 1858, and erroneously thought it had disappeared.

MAGNIFICENT METEOR SEEN ON THE 27TH OF NOVEMBER, 1862.

BY E. J. LOWE, F.R.A.S., F.L.S., ETC.

ANOTHER of those curious strangers that now and then make their appearance to astonish and puzzle us, was seen on the 27th of November.

Before describing this phenomenon, it will perhaps be desirable to say a few words, *en passant,* on meteors in general.

These bodies vary considerably in size, shape, velocity, and appearance: some are so small as scarcely to be visible to the naked eye; others, on the contrary, are two or three times the apparent diameter of the moon. Some are visible and gone again almost instantaneously, others lasting a number of seconds. Respecting their shape, they are oval, circular, kite-shaped, sharp and well-defined, or a confused mass of light—occasionally assuming extraordinary forms.

Nearly all the large meteors give the impression of being within a few hundred yards of the observer, showing how fallacious our estimate frequently is as to the distance and size of bright bodies; and this remark may also apply with equal truth to dark bodies. In a total eclipse of the sun, the dark surface of the moon has been seen apparently within two or three hundred feet of the earth, and yet it was, in reality, thousands of miles away. The meteor that has just occurred was thought to be within a few hundred yards of an observer near London, and equally near to others who viewed it from Grantham. At the latter place a gentleman was certain that it was on this side of the Wood-hill Tunnel, until it was pointed out that were this the case, there must have been a line of brighter light along its path reflected on the ground. The distance, however, had no increase of light, and the darkness caused by a steep hill on this side of both the moon and meteor was not diminished; clearly showing that it must have been far beyond this hill. From the appearance and position, as seen from Dover (150 miles S.E.), it seems to have been at least three or four hundred miles distant from Grantham. As regards size, this is also fallacious; an incandescent body of a known size does not decrease in its apparent dimensions by removal to a greater or less distance: for in some experiments it was found that the source of light appeared greater at a quarter of a mile away than it did at a hundred yards. A row of lamps in a street is not seen to decrease by distance in the same manner when lighted at night as when viewed in the daytime.

Occasionally these large bodies are seen to burst, a noise as

of distant thunder is heard, and the meteor itself, or fragments, appears to fall to the ground—the actual bursting taking place at some miles' elevation above the surface of the earth.

There are several distinct features in the light emitted from these large bodies: 1*st*, there is the light of the meteor itself; 2*nd*, a train of sparks or continuous streak left in its path; and 3*rd*, a discharge of balls from the head of the meteor. As regards the first case there seems to be great differences of opinion. From my own observations I greatly doubt the self-luminosity of a meteor; the intense light always comes from the front edge of the body, as if caused by becoming ignited, or igniting something in the region through which it passes. The great difficulty is to imagine what that something can be on the confines of the air, if not actually above the atmosphere. Aurora borealis at the same height exhibits a flame: it must, therefore, be a light-bearing region, perhaps magnetic. The friction produced by the velocity of a large body may cause the ignition. Our ordinary flame is not bright enough to produce the intense light of a meteor; the brightness of electrical light would be nearer the truth.

With regard to the train of sparks, or continuous line or streak of light often left after the meteor itself has vanished, and which in the case of a train of sparks only lasts a second or two, whilst as a streak or line of light it has been known to last upwards of a quarter of an hour—this more closely resembles a phosphorescent luminosity, that when once luminous it is with difficulty extinguished. I have seen it as a long line that has been gradually bent into a wavy line by currents. I have also seen the two ends of a straight line of this light actually unite and form a circle with stars shining within the inclosed ring. The meteor which produced the phenomenon had departed in one direction, whilst this phosphorescent luminosity was borne along at right angles to the meteor's path. The velocity is so very different; a meteor, when recorded as moving slowly, moves many times more rapidly than is the case with this luminosity—the latter is always *very sluggish* in its movements. The balls projected from the head of the meteor, usually (but I think erroneously) considered the bursting, always fall perpendicularly. The impression given is, that fragments are split from the outer edge of the body, which fall, by the law of gravitation, to the earth. The appearance of these balls is not confined to the bursting of the meteor—*i.e.*, immediately before its disappearance they are seen to be emitted as showers, sometimes at frequent intervals along its path; and these displays were of frequent occurrence with the meteor of November 27th.

The accounts given of these almost instantaneous appear-

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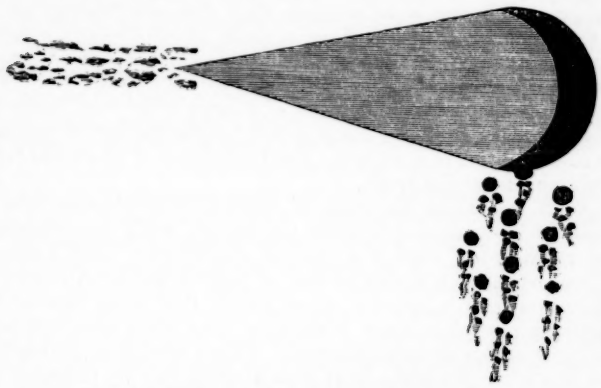
ances require to be taken with caution. With those unused to observation there is certain to be a want of steadiness; amazement bewilders the brain and frequently exaggerates the appearance; then, again, the want of proper words and terms of description, and also of the knowledge of the various features to be examined—all operate against a faithful account. This is to be regretted, because each meteor puts on a different appearance, according to the position of the observer; and this will be apparent when examining the accounts of the late meteor as seen from Grantham and Dover—two places 150 miles from each other.



METEOR AND FORMATION OF ROCKET-LIKE SHOWERS.

The meteor of 27th November was seen by myself on the platform of the railway station at Grantham under the most favourable circumstances—so much so, that there cannot be an error of five seconds in time, nor of one minute in space.

Hour of appearance.—5h. 46m. 57s. P.M., G.M.T.

Hour of disappearance.—5h. 47m. 5s. P.M., G.M.T.

Motion.—Slow.

Duration.—8 seconds.

Greatest diameter (*i.e.*, width across the head).—0° 31′ 0″.

Length longitudinally.—1° 17′ 0″.

Colour.—Blue.

Form.—Kite-shaped.

Position near β Ceti.—$\mathcal{R}$. 0h. 36m. 39s.; S. Dec. 18° 45′ 0″.

Position near Fomalhaut.—$\mathcal{R}$. 22h. 50m. 1s.; S. Dec. 30° 20′ 59″.

The meteor was somewhat kite-shaped, being nearly equal to the moon in breadth, and above twice her apparent diameter in length. (This estimate being taken by looking at the meteor and the moon at the same time.)

The light was an intense blue, but only intensely bright in the front, mostly as a crescent, but occasionally expanding to almost a circle; the remaining portion *milky-white*, and dim in comparison.

A train of sparks was left in its path, yet these only lasted from one to two seconds; balls of a blue colour, of large size (almost equal to the apparent diameter of Mars), also fell from the head of the meteor, perpendicularly downwards, not continuously but at frequent intervals (more especially between β Ceti and Fomalhaut). These balls threw out other smaller balls, which burst into star-like sparks of a yellowish colour, not unlike the shower seen from a rocket at a distance, but infinitely more beautiful.

The meteor gradually increased in size, but not uniformly; an occasional decrease in size and brightness taking place. It vanished at its maximum brightness, not bursting, but as if going behind some opaque body.

I did not see the commencement, owing to a building; but from the testimony of the Grantham stationmaster (who was on the other side) it must have commenced very near to where I first saw it: if the path were produced backwards, it would almost cross the Pleiades. My view commenced near *α Ceti*, and after progressing some distance the meteor passed almost over *β Ceti*, and then immediately above *Fomalhaut*, vanishing 4° beyond this star, and about 5° above my horizon.

This meteor gave a very strong impression that it was a *non-luminous* body—the light being produced by the *friction of its velocity on the air*.

Mr. H. P. Finlayson saw this meteor from Sandgate, near Dover, and his remarks add great interest to this appearance. They are—

"Hour of first appearance.—5h. 47m. 5s. P.M., G.M.T.

Duration.—Not more than 4s. or 5s.

Motion.—Slow.

Greatest diameter.—0° 13′.

Greatest length.—0° 26′.

Colour.—White, but reflected light bluish.

Form.—Kite-shaped, or what are called 'Prince Rupert's Drops.'

Position of appearance.—R.A. 23h.; S. Dec. 7°.

Position of explosion or disappearance.—R.A. 20h. 40m.; S. Dec. about 25°.

"Although the moon was extremely bright and clear its light

was lessened by that of the meteor; and I have little hesitation in saying that if a transit had occurred the meteor would have been seen as a bright body on the moon. There were no coloured balls seen to fall from its head, but a train of red sparks was left in its path.

"Had its path been continued backwards, it would pass about midway between the moon and the planet Mars; and if a line touching the horns of the moon and produced till it intersected the path of the meteor, it would have been nearly at right angles with it."

It will thus be seen that near Dover the meteor first came into view at the point where it disappeared at Grantham; that it was *white* instead of *blue;* that it was not nearly so large, but apparently quite as bright, and that no coloured balls fell from its head.

The Rev. John Burdor saw the formation of the meteor from English Bicknor, in the Forest of Dean, Gloucestershire; he saw a stream of sparks for an instant, which gathered, as it were, into the meteor—one or two solitary sparks at first, increasing to a stream until the meteor was formed, and then the meteor itself increasing in glory and volume until it vanished. The colour most intense blue. The height above the horizon was guessed to be 60°.

At Streatham Hill, London, it had the appearance of being in a state of incandescence, surpassing the electric light in brilliancy, if possible. It disappeared without any apparent explosion about 5° beyond, where it became invisible at Grantham.

At Sutton Courtney, near Abingdon, Mr. John Kent says there was a slight explosion similar to that of a percussion-cap, and this attracted his attention to it; he considered it remarkable how suddenly it disappeared, there being apparently no obstacle to hide it. Mr. J. Seeley, who saw it from Hazeby Heath, Hants, was also struck with the suddenness of its disappearance.

At Bridport, in Dorset, Mr. Charles Walker saw it rise in the N.E., move horizontally, and disappear in S.E. We estimated its greatest height at about 20°; its shape conical, with a circular base, the latter moving foremost. The apparent length was rather greater than the diameter of the full moon, and the greatest breadth about half its length.

Mr. Philip Barrington saw the meteor from near Bray, county Wicklow. It appeared almost due E., and moved rapidly to about due S.E., lasting only a few seconds. It seemed about four times the diameter of the moon in length, and half its diameter in breadth at the head, tapering down to the extremity of the tail. It moved nearly horizontally at an altitude of 5° or 6°. A number of sparks were left behind in its

progress, and just before its disappearance it threw out the most brilliant light, blue and green, like the explosion of an enormous rocket.

Mr. A. P. Falconer, of Lymington, Hants, saw a great light issue from the sky, and increase in size as it approached him. He says, "I was then standing in a line due S. with the needle rocks; as it advanced to this line, suddenly it cast off sparks in the same way as is seen to fly off from the blows of the smith's hammer off a piece of hot iron; on its N.E. limb and under it these lumps of fire and flame flew off in curls, some falling down whilst part formed a broad expanse of light behind it, *crimson-red* interlined above with *greenish-blue*, and below *bright yellow*. The ball of light was *bright blue*, and it was like a Roman candle. I fancied as it cast off these sparks it seemed impeded in its course, and apparently to *forge* its way along. Its size increased as it approached me; I feared these sparks, discharged so abundantly, would set fire to my hay and straw ricks; these ceased, it turned more southerly, then quickly whirled to the S. (*due*), between the earth and the moon (which was then over it), and vanished away."

The meteor, as Mr. Falconer observes, was impeded in its course; there was at Grantham a momentary check in its velocity each time it discharged a shower of balls.

THE EYE AND THE MICROSCOPE.

BY HENRY J. SLACK, F.G.S.,

(Member of the Microscopical Society of London).

It is a common, but fortunately an erroneous opinion, that the use of the microscope is necessarily followed by injury to the eyes. It is no doubt true that those organs are often fatigued by looking through the optical arrangements by which the minute world is made known to us; but the inconvenience generally results from causes capable of removal; and it is not too much to affirm that very few miscroscopic studies, whether pursued in the day-time, by the help of natural illumination, or of an evening, by the aid of appropriate lamps, have any inevitable tendency to debilitate the sight. Experienced observers are well aware of this fact, and unless their researches have demanded unusual exertion, they can report, after ten or twenty years' labour, that their visual apparatus has not deteriorated any faster, if so fast, as that of their

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neighbours, which has never been employed in seeking the information which lenses are able to afford.

In the earlier days of optical science, it was impossible to imitate the natural conditions of good and pleasant sight, either with the microscope or the telescope. The eye possessed advantages which no artist was then able to reproduce in optical combinations; and hence every attempt to extend its powers involved the necessity of putting up with serious defects. These unfavourable circumstances have been so far changed, that it is now possible to make telescopic, or microscopic, vision almost as clear and as easy as if no instrument intervened. To do so, however, requires a close copy of the natural conditions of satisfactory sight. We see objects most agreeably and correctly at a certain distance, with a certain quantity and a particular direction of light; and it is also necessary that they should be, or appear to be, of a sufficient size. To stare at a white house in the full glare of sunlight, to strain every nerve in order to make out dim outlines faintly and uncertainly looming through a fog—these are things which everybody knows are painful and mischievous; and if we make our microscopic experiments under a similar blaze, or in a similar mist, we shall easily produce an analogous effect. If, on the other hand, the light falls softly, and in right quantity, upon or through our object—if the power employed is sufficient to make the details clear, and the whole arrangement is good—the sensation will bear so close a resemblance to that of the normal vision, that little or no fatigue will be felt.

This question is important, because on the one hand many persons hesitate to become microscopists from a fear that their eyes will not bear the strain; and, on the other hand, scores of people who have purchased instruments, give up their use because they do not succeed in seeing through them with satisfaction and ease. The first essential requisite is to obtain a microscope free from important defects, and unless it is convenient to spend a large sum of money at once, it is better to have only two powers, and a sufficient quantity of apparatus to use these with the best effect. Furnished with a microscope having a body about ten inches long, or if shorter with a Kelner eye-piece—which to some extent remedies the want of length—and two objectives of one inch, or two-thirds, and one-quarter, or one-fifth focal lengths, and with two or three eye-pieces, the student can verify the majority of observations of general interest in the animal and vegetable kingdoms, and he can examine for himself all the objects he is likely to collect. A greater array of powers is often convenient, and even indispensable for special purposes; but it is of far more consequence

to use those mentioned well, and they must, under any circumstances, form the staple instruments of research. The lowest of these powers, the inch, or two-thirds, should have a perfectly flat field, and evince no sensible defects if made to give four times its ordinary magnification by a higher eye-piece and a few inches of the draw-tube. A well-made section of an echinus' spine is a good test for flatness of field—the margin and the centre should come in and go out of focus together. That elegant Diatom, the *Arachnoidiscus Ehrenbergii*, will likewise supply a fair but by no means a difficult test of defining power. Let us imagine a beginner trying to show these two objects. In the first place, let him take the echinus' spine, the inch or two-thirds object-glass, and the first eye-piece. Having got the spine in focus, the mode of illumination will decide whether it can be seen without wearying the eye. The microscope ought to have the mirror below the stage so mounted as to move up and down, and right and left, and to assume a position at any angle with the plane in which the object lies. Candles should be avoided as a source of light. They are too unsteady and continually vary in height. Discard them, therefore, and buy a small paraffin lamp for a shilling or eighteenpence.* It will be high enough for many purposes, and can be raised when required by a block of mahogany or a book. As a general rule, the source of light is required at two elevations only—one suited for transparent illumination with the mirror under the stage, and the other to enable the bull's-eye to condense the rays upon any substance to be seen by the light which it reflects. The lamp should, except in some special case, be placed on the left of the observer, a few inches from the microscope; and to prevent his eye being distracted by its glare, a shade should be employed. This is made of various patterns to suit different fancies, but the simplest plan is to take a piece of *thin* flexible cardboard, about nine inches by six, cover it with black cotton velvet, which has no lustre, and make a hole in it through which the tube of the microscope, immediately below the eye-piece, can be introduced. Supplied with this screen, both eyes should be kept open, and the object steadily viewed as soon as the focus has been accurately arranged. Then take the mirror, which we will suppose to have been turned so as to throw some light through the echinus' spine, and observe the effect of slight changes in its position. The whole field should be equally lit, or fatigue will ensue from some portions being seen worse than others. There should

* Many observers will prefer a superior lamp, and they should inspect the elegant and excellent pattern devised by Mr. Pillischer, the optician. In addition to being good for the microscope, it is one of the best reading-lamps yet introduced.

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be no glare. With a naked lamp this can be avoided by regulating the quantity of the light, and paying attention to the angle—a little obliquity having a softening effect. A ground glass globe gives a pleasant repose, and the same, or a better effect may be obtained by melting a bit of spermaceti on thin paper, and cutting a disk of the preparation thus made, which may, according to its size, be dropt over the largest hole of the diaphragm, or placed on the flat side of the bull's-eye lens. The latter is the best plan, as it causes no interference with an oblique direction given to the light by turning the mirror. The student must not imagine he has illuminated the echinus' spine properly until every portion is clear; no part being enough in the shade to diminish its distinctness, and none too bright to be seen without pain.

Having thoroughly succeeded in illuminating the echinus' spine as a transparent object on a light ground, so that it can be seen as comfortably as a willow-pattern plate one foot from the eye, let the mirror be thrown out of the plane of the instrument, and at such an angle that none of its light can fall directly upon the object-glass. If this be accomplished, the ground will be dark, and the object will stand out in strong relief seen by the light it is able to refract, or bend back to the plane of the instrument. This produces a beautiful effect, and is sometimes superior to the dark ground illumination afforded by the parabola or spotted lens. What has been previously said about uniform distribution of light should still be attended to, as the want of this uniformity is a frequent cause of distress to the eye.

It is customary to treat the parabolic illuminator as if it were a difficult instrument to manage, but after a month or two's practice with the stage mirror at various angles, it may be advantageously employed, and has an admirable effect, not only in giving beauty to a large range of objects which possess the necessary refractive power, but in rendering visible points of structure which other modes of illumination do not readily disclose. For example, the red eyes of rotifers gleam like rubies in its light. The action of the parabolic illuminator is to throw through an object a cone of rays at such an angle that none shall enter the objective until refracted by the substance under view, which, if suited to the purpose, stands out with great brilliance on a black ground. The stop with which it is provided should usually be pulled back and a strong light thrown up the instrument from the stage mirror, which should receive a good supply of light from the bull's-eye or condensing lens, having in this case its flat side to the lamp. It is usual to recommend the use of the *plane* mirror, but the concave one generally answers best. The parabola should be

gently moved backwards or forwards till the best condensation of light is obtained.

The lesson with the echinus' spine is not yet over. It should be seen as an opaque body, with the bull's-eye lens, with the lieberkuhn and dark well, and with the side silver reflector. If the bull's-eye is intended to give a strong spot of light, its *convex* side may be turned towards the lamp; but when employed to increase the quantity of light which falls upon the mirror, its flat side should occupy that position. The lieberkuhn is very easily used, and if a few shillings do not matter, it is better to get a set of dark wells from the optician than to make shift with spots of velvet or lamp-black upon a glass slide. The side silver reflector cannot be recommended to a mere beginner, but after a few months work has given some skill in manipulation, it is a valuable aid. It is best mounted on a stand like a little bull's-eye, and should have motions in all directions, including the means of changing its height. When it is to be used, place the lamp on the *right* hand, the bull's-eye in front of it, and the silver reflector on the left, so that it may catch the light, which will be thrown across the stage. Thus arranged this piece of apparatus has several advantages. It gives light with one reflection from a single surface, which has no tendency to become chromatic, and it affords great facilities for oblique illumination. With such an object as the elytron of the diamond beetle it has a gorgeous effect, and, at the same time, brings out fine lines which an equal amount of light less judiciously applied would efface. It will not do so well with the echinus' spine, as the method of dark-ground illumination already described; but the student should try this, and other objects, in every possible way, and will thus acquire manipulative skill and judgment concerning the best plan to employ.

Having gone through a set of illuminating experiments with the echinus' spine, repeat them with the slide of arachnoidiscus, and specially note the beautiful appearance which these diatoms present when the parabola is used. They then resemble the exquisite filagree-work which the Maltese execute in silver; and if the parabola is suddenly removed, and light from the mirror under the stage sent through the object a great change will be noticed in the disposition of the light, and dark lines. The markings of the arachnoidiscus must be displayed as they are shown in good drawings whatever mode of illumination be employed, and it is well to select a slide containing, in addition to one or two arachnoidisci, some other large diatoms, such as *Triceratium, Biddulphia,* etc., which can be displayed with the same power.

The objects recommended for the first lesson in such a use

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of the microscope as will not injure the eyes, may be varied at the pleasure of the student, but it is well to begin with those that can be shown with a low power, and which, either singly or in groups, occupy all the field. Another class of objects do not want more magnification for their efficient display, but are not big enough to occupy so large a space. The tarsal joints of the feet of many insects, their spiracles and mandibles, belong to this category. Now, if such objects are surrounded by a flood of bright light, they will not be distinctly shown, and the eye of the observer will be uncomfortably affected. In these cases the object should be arranged exactly in the centre of the field, as a symmetrical appearance is more agreeable and less fatiguing than the aspect of anything that looks askew. In the next place, the light must be moderated by obliquity, by the spermaceti paper, or by some other mode. The least troublesome of these methods is the spermaceti paper, or a piece of semi-transparent white glass made for the purpose. If the object needs a very strong light to make it sufficiently transparent, the best plan is to use an achromatic condenser and allow a sharp pencil of light to reach it through one of the smaller stops. The value of the achromatic condenser for showing difficult objects is well known, but its advantage in saving the eyes is less recognised than it deserves. Many things, such as portions of insects, can be seen distinctly without it, though with a fatigue which is avoided by its use. When employed with low powers the usual plan is to remove the upper part of the combination so as to bring its focal length below that of the objective employed. In many cases, however, it is better to use the whole, which we will suppose to be a quarter-inch power, and to throw it out of focus, so that the rays will cross before reaching the object. This plan, with the use of one of the smaller holes or stops, gives enough light for many purposes and prevents over excitement of the eye.

No student who wishes to work efficiently with a quarter-inch, a fifth, or a higher power, should begin with either of them; but first learn to use an inch or two-thirds with the various methods of illumination which we have indicated. If premature efforts are made to obtain considerable magnification, disappointment will inevitably result, and so far as what Dr. Kitchener termed the "economy of the eyes" is concerned, it should be remembered that every increase of power augments the difficulties of obtaining a clear and pleasant view. An experienced manipulator will show a properly selected and prepared object with the highest objectives without any sacrifice of convenience or distinctness; but it is only after considerable practice that a beginner will be really successful with a quarter-inch. The popular notion of the necessity for magnification is

quite wrong, and the common exclamation, "That must be a very powerful microscope," is a frequent indication of this mistake. High powers are needed to exhibit details that can have no meaning, and often no beauty, for those whose minds have not been previously prepared to appreciate them by a broader acquaintance with the complete structure of which they form a part. Thus the same steps which the microscopist should take for the preservation of his eyes, lay the best foundation for the more difficult operations, in which the employment of higher objectives and of niceties of illumination become indispensable.

When a good set of experiments have been made with an inch or two-thirds objective, and the difficulties of microscopic vision have been sufficiently conquered, a similar course should be commenced with a quarter or a fifth object-glass. Objects that are severe tests of the perfection of such glasses should be avoided until those which are easier have been successfully displayed. The scales of the *Vanessa urticæ*, and that pretty diatom the *Pleurosigma hippocampus*, will do admirably for a beginning, taking them in the order mentioned. The butterfly scales require a clear, steady light sent through with little obliquity, and the mirror must be turned so that the illumination leaves their edges clear all round. If one side appears shadowy, there is some fault in the angle at which the light falls; and if the unoccupied part of the field is too brilliant, either the light must be reduced by turning the lamp a little lower, or the distance of the mirror from the stage must be altered, or the spermaceti screen interposed.

The *Pleurosigma hippocampus* will give good practice in regulating the obliquity of the rays from the mirror. It is a very easy object for a good manipulator, but a beginner must not be surprised if he makes a hundred trials before he can quickly and readily show the two sets of lines as plainly as he can see the pattern of an engine-turned watch. As a rule, no more light should be used in displaying any object than would be sufficient to imitate the brightness of a larger object of the same kind as seen in the diffused illumination of a fine day, and it is often desirable not to exceed that of a shady room in the summer time. When the lamp and optical contrivances have been judiciously arranged, an increase or decrease of light can be obtained by turning the wick a little higher or lower, and if an observation is prolonged, less light will suffice than for a temporary glance, as the eye is more willing to accommodate itself to a moderate illumination than to grow accustomed to anything like a glare.

A magnification of two hundred linear or upwards can only afford easy vision with objects that are very flat, as slight inequalities of surface inevitably throw the salient, or retreating, por-

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tions, as the case may be, out of focus. As a general rule, the larger the angle of aperture of the object-glass, and the more oblique the rays it can receive from the surface of the object, the more cloudy will be any parts that are not focussed to a nicety, and hence, for ordinary use, it is well that a quarter-inch power should not exceed about 80 or 90 angular aperture, and a fifth a little more. The impossibility of making any high power work well on uneven objects indicates a practical restriction of their use; and when they must be employed upon things which they can only show in part, no attention should be paid to what is indistinct. This habit is easily formed by concentrating attention upon that which is seen well; and if this is accomplished, a fertile source of optical discomfort is removed.

Let one more hint be given on the avoidance of injury to the eye. Secure steadiness in the instrument, the table, and the place of observation. It is extremely fatiguing, and taxes the brain as well as the eye, to try to make out the details of objects that are fidgetting about. Slides merely require a good instrument, a table which no one shakes, and a room in which no one runs or stamps about; but live things must be restrained by slight compression, or by a loop of thread, which when pressed down in the live box, forms a sort of cage, the whole of which can be taken in by the power employed.

It would be easy to prolong these hints on the eye and the microscope; but if, the student can be set to work in the right manner, he will soon be able to profit by the labours of well-known writers; and if, during the first three months of his engaging in microscopic pursuits, he will determine never to be satisfied unless his objects are seen as easily and as plainly as the furniture of the room, he will not, in any subsequent portion of his career, complain that the employment of the most fascinating of optical instruments has injured his sight.

EXPERIENCES OF HASCHISCH.

BY SHIRLEY HIBBERD.

THE translation of a note by M. S. de Luca, on Haschisch, which appeared in the December number of the INTELLECTUAL OBSERVER (page 346), recalled to my memory some experiences of my own in the use of Haschisch. These experiences might not be worth recording were it not a matter of some interest to the medical profession whether or not Haschisch can be exhibited as a therapeutic agent, a matter to be determined very much by a comparison of its effects on persons of various habit and constitution. It may be right to preface these remarks by stating that I am of middling height, spare habit, sanguine-nervous temperament, not robust, but have always enjoyed sound health, have great powers of endurance, and possess altogether a vigorous constitution.

The publication, in 1845, of a work on Haschisch, by Dr. Moreau,* occasioned between myself and a friend, who was then preparing for the medical profession, some conversations on this and other narcotics, the result of which was that we several times smoked and swallowed opium, and resolved also to possess ourselves of some Haschisch. We made application to Messrs. Battley and Watts, the druggists, of Fore Street, without success, and, after other fruitless efforts, gave up the hope of ever tasting the fascinating compound of *Cannabis Indica*. In 1849 my friend was sent to Paris, and he soon after wrote to me to say that the students at the Medical Schools were all indulging in the intoxication of Haschisch, and by the next post he would forward me a sample. In due time I received a small brown slab, resembling a refined sample of Cavendish tobacco, and with it instructions to take not more than one drachm at a time. I was so eager to make acquaintance with it that I could have taken the whole at once. It weighed about half an ounce; it emitted an agreeable odour when broken, and felt sticky between the fingers. I trembled with joy as I turned it over and over in my hand, and I thought the odour affected me so as to produce a sense of inward satisfaction, like that of the first few whiffs of a good cigar. I retired to my study, it was then growing dusk, the season July, and I had been up two nights in succession reading Jacob Behmen. I remember feeling quite fatigued and low, yet in perfect health, and in the mood for any wild freak which might promise a sensation agreeable to the imagination. I sat down at the window, broke off a piece of the cake as near a drachm as I could guess, and swallowed it. I put away the remainder, that

* "*Du Haschisch et de l'Alienation Mentale Etudes Psychologiques.*"

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I might not be tempted to take a second dose, and waited anxiously to feel its effects.

I soon became conscious of a sense of disappointment. I said "That was not Haschisch, but some preparation of chocolate." I took my pen to write an indignant letter to my friend, that he might know I had not become an easy dupe to his plan for deceiving me. I was at a loss how to begin the letter, though otherwise always ready at writing, even when fatigued. For a moment I paused, considering, and then the parietal bones of my head expanded widely, as if parting at the sutures, and again collapsed with a sort of shuffling sound. I said, "This is the result of fatigue; I have read too hard, I will go to bed." As I rose from my table I became conscious of an agreeable state of warmth and lightness; I felt as if I had taken Scotch whisky. The room seemed larger than usual, and getting larger and larger still; some skulls of animals on the walls acquired colossal proportions, and the conviction entered my mind that I had realized an old dream of living in the midst of the monsters of the Oolitic period, and that I had been awe-struck for years, immoveable, paralyzed, and with every faculty benumbed, except the faculty of wonder. I caught sight of my watch hanging in front of some papers on the wall, it at once dispelled the illusion. I calmly looked at it, and found it was just twenty minutes since I swallowed the Haschisch. Immediately the watch expanded to vast dimensions, and its ticking sounded through my head like the pulsation of a world. I knew now for the first time that I was under the influence of the drug, and began to make a few notes in pencil. Suddenly my limbs seemed benumbed, my toes shrunk within my slippers, my fingers became like the long legs of a convulsed spider, I dropped the pencil, and walked to the window. The landscape was so sublime that I forgot the cause of the illusion in my admiration of the magical scene. The horizon was removed to an infinite distance, but was still discernible, and the sunset had marked it out with myriads of fiery circles all revolving, mingling together, expanding and then changing to an aurora, which shot up to the zenith, and fell down in sparks and splashes among the trees, which at once became illuminated, and the whole scene was grand beyond description, with fires of every conceivable colour.

All this time the landscape continued to expand, everything grew as I looked on to greater and greater proportions. Trees shot up higher and higher; their branches overspread the sky; they met together, and became a confused mass; the lights, which just before had glowed on every hand, changed to a general purple haze, a sense of twitching in every limb, coupled with a feeling of weariness and depression, caused me to turn aside

and sit down. The twitching changed to a sharp pricking sensation, most violent in the extremities, and for a moment the thought crossed my mind that I had been poisoned by strychnine. I opened a drawer to find an emetic, but the drawer had gone, and in its place sat one of my antediluvian monsters grinning at me—a real icthyosaurus, with a red cap on its head, and with drum and pandean pipes. For about six weeks —so at the time I determined the period—it played a monotonous tune, while I sat on the ground laughing and enjoying the idea of my toes and fingers being elongated into claws, when suddenly the thought seized me that I would destroy the illusion by an effort. I dashed at the monster, and my hand fell on the handle of the drawer. The dream was dissolved, and I could clearly understand that the ticking of my watch and the singing of a bird in the garden, were the real sounds which my fancy had changed to the drum and pipes of my Oolitic companion. I once more looked at my watch, and though years seemed to have elapsed since the spell began, I found the real period to be but twenty-five minutes.

This last act of observing the time threw me again off my balance. I said, "Twenty-five minutes, twenty-five days, twenty-five months, twenty-five years, twenty-five centuries, twenty-five eons. Now I know it all; I am the alchemist who discovered the elixir of life in the dark ages, and I shall live for ever; what is time to me? Yes, that was the elixir I took twenty-five minutes ago to experience a sensation, and there it goes round the room." It made me giddy to see it whirl like a wheel of which I was the centre. There was a bust of Milton on the shelf which had changed to the face of Jacob Behmen, and it sat on one of the spokes of the wheel, and smiled upon me with such a smile of peace and satisfaction that I shouted "Ha, ha!" The wheel revolved; it became brilliant with fiery corruscations, and by degrees the centre where I sat became the circumference, and I was whirled with it, my head opening and shutting, so that I could feel the cold air upon my brain; my breath getting short and difficult, my chest falling in as if crushed by a weight, and my stomach gnawed by rats. This went on for ages, yet I knew all the while where I was, and how the whole thing had happened; and actually got up, rang the bell, and ordered some coffee, though not for an instant did the illusion cease, nor, so far as I ever learnt, did the servant who answered me discover any signs of my aberration. I thought of the coffee as likely to relieve the sense of oppression and disorder, which was now fast dispelling the illusion by its reality. I felt my pulse, and tried to count it; I knew afterwards that it was full and rapid, but at the time the throbs were like the heaving of mountains, and the numbers would

multiply themselves; so that as I counted "one, two, three," they became "one, two, three years, centuries, ages," and I literally shrieked with the overpowering thought that I had lived *from* all eternity, and should live *to* all eternity in a palace of coloured stalactites, supported by shafts of emerald, resting on a sea of liquid gold, for this was now the appearance of things; and the gnawing at my stomach suggested the idea that I should be starved to death and yet live, the deformed wreck of a deluded man.

At this moment there was a tap at the door, and the servant entered with the coffee. It was in a huge tankard chased all over with dragons that extended all round the world, and I saw the odour of it play round her in circles of light, and for at least an hour she stood smiling and hesitating where to place it, because my table was covered with papers. I very calmly removed a few of the papers, and heaved a sigh that dissipated the dragons, made the odours fall in a shower of rain, and she put down the tray with a crash that made every bone in my body vibrate as if struck by ten thousand hammers. I know not whether she was alarmed at my appearance, but she stood apparently aghast, and her rosy face expanded to the size of a balloon, and away she went with the rapidity of lightning, with Mr. Green in the car, and I stood applauding in the midst of thousands of lamps, which I had time to note—as the scene continued during a period which seemed indefinite—were all glow-worms, which I could touch, and they communicated to my fingers phosphorescent sparks, as if they had been rubbed with lucifer matches.* But I knew this was unreal; and I drank the coffee with the most perfect composure, though I felt it difficult to pour it out without spilling it, and the cup came to my lips as if it were the rim of a cauldron seething with a stew of spices and nepenthe, and amid the steam I could see the fierceness and tartness and prima materia of Jacob Behmen, all displayed, so that there was an end of the mystery, and I could see into his brain, as he now seemed to be looking into mine.

The moment I sipped the coffee it darted through me, and caused sensations of insupportable heat. The gnawing sensation of the stomach and contraction of the chest gave way to a sense of pricking, most violent in my fingers and toes, and yet, though painful, this was all pleasant; and though I could now collectedly observe the objects around me, yet they would transport themselves to immeasurable distances, and keep con-

* Only a few days before I had found some glow-worms in the garden, and on handling them found my fingers tipped with a dull phosphoric glow. This probably gave rise to the illusion. In fact, I afterwards traced many of my sensations during the paroxysm to previous events, and I almost believe the illusions are the result of abnormal memory.

tinually dilating in size; and though I looked at my watch, and saw that only forty minutes had elapsed, yet there was a secret persuasion in my mind that a period of at least forty centuries had gone by since I broke off a fragment of the cake, and committed myself to this dream.

There seemed to be now only one effect of the drug remaining, and that was a sense of warmth all over the body and a tendency in my head to expand and fill the room. But my arms dropped down; I could not keep them up without great and painful effort. I finished the coffee, experienced less of the pricking sensation than at first, and then rose and went to bed. I could walk without difficulty, though my legs were immensely long, and felt as if they would presently be cramped, so that I should cry out. As I undressed myself, my clothes would fly from me far away into boundless space, and become wandering stars, the buttons of my vest glittered in the firmament like Orion, but much more vast and splendid. I did not dare to look out of the window; I endeavoured to control myself, for I began to feel a sense of dread. As I got into bed, the bed extended; as I lay down at full length I myself extended, and as soon as I shut my eyes I felt that I covered the space of the whole earth. I had a sense of indescribable pain all over me; my skin seemed to move to and fro upon my flesh, my head swelled to awful dimensions, and I parted in two from head to foot; became two persons, each throbbing, breathing hard, sighing loudly, and lost in a commixture of ethereal yet agonizing colours and sounds. These seemed to continue for ages; but I was really asleep, and I never could call to mind at what time I went to bed, or at what point of the illusion sleep came upon me, but I always supposed it to be when I felt myself parted in twain, and immersed in light and music.

The next day I was awake early, and seemingly unrefreshed. I lay some hours pondering on the strange effects the drug had produced, and found it difficult for some time to prevent the intrusion of some broken fragments of the visions from taking possession of me; but when I had dressed and breakfasted, I felt as well as usual, and experienced no sensation whatever, which I could attribute to the effects of the drug.

In a second experiment, when unaffected by fatigue, I noticed that every physical and mental power seemed intensified. The illusions were more agreeable, and more ridiculous. I was the subject of a thousand different moods in the course of a few seconds, which, as in the former cases, seemed ages, and these moods were nearly always swallowed up in some strange vision of walls receding, landscapes rolling away to an horizon they never reached; skies opening to views of boundless space,

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and sudden flashes before the eye of visible odours, sounds, and ideas. The most remarkable feature of this paroxysm was a feeling that my soul was too large for my body, and must expand it to suitable dimensions. This pained me. I gasped for my breath, and felt my skin stretch and crack, and my joints fly like the snapping of huge beams of timber. These illusions became instantly the foundations of others. The cracking of my skin became suddenly a display of fireworks; and the snapping of my joints, the beating of gongs. Still pleasurable sensations prevailed; old memories were revived as pictures, and in many respects the effects resembled those of opium. But with opium there is a more entire and settled acquiescence in the illusions, and the ideas are more connected and continuous. With Haschisch there is a rapid succession of new scenes and startling combinations. When there is no pain the mind is literally whirled away in a succession of ravishing delights, and is yet all the while conscious that the whole affair is a deception. This paroxysm was soon over. It ended in a joyous feeling, in which life seemed lengthened out beyond the natural term, and all around me were objects of transcendant beauty, which I had the power of resolving into realities by an effort of the will; and it seemed that by successively using this effort the spell was broken, and the effect of the drug entirely destroyed.

The third dose was the last. I took it at mid-day, when in my usual health and spirits. Thinking that at the second experiment I did not take enough, I now weighed out four scruples. I at once went out, and proceeded across Finsbury Square, in the direction of the city. It seemed that about a quarter of an hour elapsed, during which I had felt a comfortable sense of warmth, and an increasing tendency to open my mouth for air, though I was not aware of any difficulty of breathing. "Now," said I, "this is pleasant. I shall have a glorious time of it." Immediately a voice shouted "There he goes; he's always inflated!" I was at once conscious that I was observed by passers-by to be expanding rapidly; and I felt myself rise from the ground, and walk above it. I halted, and by an effort of the mind collected myself, and found that the voice was that of a man selling some wares in Moorgate Street, who had not even noticed me, nor had any one else. But the thought occurred immediately, "This is a delusion, I *am* expanding, and cannot touch the ground." For a moment it might be, but it seemed an indefinite period, I saw the whole of the city spread out before me as a diorama. The church bells rang joyously; the houses were illuminated; the horses had gold and silver trappings; the people were waltzing, singing, laughing, and playing with fireworks. I again exerted my will, and felt a disgust

at the meanness of such a performance, so far short did it come of my own sense of sublimity; for I felt exalted, and had the utmost consciousness that I was able to separate the false from the true, though I really could not. I retraced my steps, and was accompanied home with triumphal bands of music, shouts of triumph, running footmen, carrying coloured flambeaux; and I gradually quickened my pace till I ran too, only touching the ground at intervals, but for the most part swimming through the air; yet knowing that I walked as other people, and knowing too, that the ordinary sounds and scenes of the streets were the foundations of the whole delusion.

I reached home, and went to my study with a sense of satisfaction that I was now in a safer position than in the streets under such an influence. I sat down, and began to fill a pipe with Turkey tobacco. The pipe would lengthen out so that I could not reach the bowl, yet I did reach it, and in like manner the tobacco jar seemed deep enough to serve for one of those used in "Ali Baba, or the Forty Thieves!" and it suddenly became a row of jars, and out of them leaped the forty thieves, with monkey's faces and red jackets on.* I lighted my pipe, and as the cloud rose, I saw the party had all lighted their pipes, and were all proper Arabs, and I was in the midst, about to tell them a tale.

By some strange freak they all suddenly collapsed and became the double of myself, and yet they continued smoking. I now saw in the stomach of my double a huge cake of Haschisch, which presently shot up into his brain, and I felt a hot throbbing of the head, and the thought occurred, "Why, if he has the Haschisch, have I the burning, and how can that shadow smoke so calmly with a mass of poison in his brain?" I rose and propounded to my double a problem, "How, in the end, matter and spirit would be completely identified and made as one?" I was assured, in reply, that a sense of lightness would accomplish all, and I became light as a feather; I swayed to and fro, I was lifted up, sparks flashed in my eyes, fire was emitted from my fingers, my head, my stomach; and presently there was an awful crash, and I came to myself with the thought that I was going mad. I saw the pipe in fragments at my feet, and the burning tobacco on the hearthrug. I coolly picked it up with my hand, took another pipe, dropped the smoking tobacco into it, and saw my double again. This time he was the body and I was the shadow. I felt myself to be nothing; I was the soul, and beside me was the body. I thought I had now solved the problem of matter and spirit. I

* I had seen a monkey on a barrel organ during my walk, and tested my sanity by noting all its zoological features, in order to determine its species; but I lost it suddenly.

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said, "They are only two forms of the same fact," and I laughed aloud, and they all laughed with me—the umbrellas, I mean—for my umbrella hung on a hat rail, and it peopled the room with offspring, and away went the furniture and ornaments and books, all carrying umbrellas, dancing, whistling, and splashing the water from the pools upon me till I stamped my foot and smothered myself with sparks, and planets, and auroras, and sank back with a pain in the head that literally dispelled the delusions, and created a momentary alarm. I was now beset with prickings; I seemed to swell; I had a difficulty in breathing—and yet it was a pleasant one. I put the tobacco away, inspected everything about me, and thought of trying the effects of reading aloud, and of attempting to sing; but I found my strength gone, I was spell-bound, so light I could not govern my movements, and by degrees I began to discover that the illusion was over, that it had left me tremulous, and with a low pulse, and requiring refreshment for my recovery. The first act on fairly reviewing the case was to seize the fragment of Haschisch that remained and fling it up the chimney. It went up, and did not even return again; I saw it go into the sky and become a bird, for the chimney was glass, and I could see through all its windings. I now felt that madness had really come upon me, and I began to bathe my temples and drink soda-water, and soon discovered that I had had a second paroxysm, for there lay the Haschisch among the shavings in the fire-place. I applied a match, there was a glorious blaze, and I now saw it dissolve into a grand procession of coloured lights, that died away and left me quietly and collectedly reflecting on the whole affair. This was the third paroxysm. There was yet one more, but of a trivial nature, and I had now done with Haschisch.

Having at that same period of my life frequently indulged in the use of opium, I can compare its effects with those of Haschisch, and I notice this great distinction as regards my own experiences:—With opium the mind and body become alike contented. Pain soon ceases after commencing to smoke a pipe in which a fragment of opium is mixed with the tobacco. On the other hand, Haschisch causes pain, and many unpleasant sensations are mingled with the most delightful of the visions it presents. Another distinction is that opium always causes some amount of nausea when its pleasurable effects are over. Haschisch leaves a slight depression, but the stomach does not appear to be affected; but this might be different if the use of Haschisch became habitual. Another distinction is, that the mind can pursue a train of thought logically while influenced by opium, but Haschisch causes so many alternations of feeling, that sequence is destroyed.

Some readers of this may associate the subject with the recollection of an act of discourtesy on my part. On the 12th and 19th of June, 1850, I delivered two lectures at the London Mechanics' Institution, in the course of which I gave an account of the effects of Haschisch on myself. Something like a Haschisch society was formed there immediately afterwards, and I was requested to furnish the material for gratifying the wish of the young men to understand Haschisch at first-hand. A readiness to oblige led me astray; I consented. I obtained a large cube of Haschisch from Paris, and was about to send it on to the gentleman who had corresponded with me on the subject. I felt that I might be the author of incalculable mischief, so I destroyed the cake, and purposely sent no word of explanation or apology. I thought if I now refused they would get it by some other means; but if I remained silent, the enthusiasm for Haschisch would die out in disappointment. I know not if my discretion at last was equal to my folly at first; but if any of those persons read this, I wish them to understand that it was for their good I adopted such a method of disappointing them.

THE FLYING LIZARDS OF THE SECONDARY ROCKS.

BY HENRY WOODWARD, F.Z.S.

(*With an Illustration.*)

THE discovery of the remarkable fossil animal in the Lithographic Limestone of Solenhofen, which was described in the INTELLECTUAL OBSERVER for December last, has naturally awakened great interest in all inquirers into Zoology.

This interest has been still more strongly excited by the statement of the high authorities, Drs. A. Wagner and H. Von Meyer, that this creature *was not a bird*, but a long-tailed flying lizard furnished with feathers. Having, in our description of the *Archæopteryx* (as it is now definitely named), informed our readers of the positive reasons for regarding it as a bird, we are happy now to be able to show, on the other hand, that it is not a reptile. Since that description was in print, another instalment of Dr. Häberlein's magnificent collection has been received at the British Museum, and in it are two most instructive specimens of the very genus of long-tailed Pterodactyles, or *Rhamphorhynchus*, with which our fossil bird has been compared. These admirable specimens, the first ever brought to this country, have, together with the two slabs containing the *Archæopteryx*, been placed in the glass cases of the Geological Gallery, so that they are now within view of all who desire to see them.

XUM

The reading of Professor Owen's paper before the Royal Society being deferred until the 20th November, we were unable to use his valuable anatomical observations and comparisons in our article. It is with pleasure, therefore, that we now record that, in deference to H. Von Meyer (who had a year before described and named a single feather from the same quarry which furnished the fossil bird), Professor Owen has withdrawn his MS. name and adopted H. Von Meyer's, *Archæopteryx;* giving it, however, the specific name of *A. macrurus.* The structural peculiarity of the fossil bird, in which it differs essentially from all known examples of the class *Aves,* is in the apparent possession of two unguicular digits, armed with hooked claws, attached to the carpal bones of each fore-arm. These, we suggested, might be *analogous* to the spurs on the wing of the "Screamer" and "Spur-winged goose;" but might more probably *correspond* with the prehensile thumb on the wing of the bat, or the small fingers of the Pterodactyle.

Professor Owen considers the long tail to indicate a *more generalized* type than is seen in recent birds, which are *specialized* by a form of tail which may be regarded as characteristic of the class. He cited instances of the changes which the vertebræ undergo in the embryo of recent birds as illustrative of their affinity with *Archæopteryx.* Thus, in the embryo of the rook twelve free caudal vertebræ are found; but before maturity five or six of these have coalesced to form the sacrum, and three to make the terminal joint of the tail. In the embryo ostrich eighteen to twenty free vertebræ occur, but seven or eight unite in the sacrum, and two or three in the last joint. This arrangement is also found in the embryonal development of the class of Fishes; for all fishes are *Heterocercal* (odd or uneven-tailed) in the embryo, although most modern fishes are *Homocercal* (even-tailed) afterwards. Again, in the *Reptilia* we have many familiar instances of this general type of structure. In our common fresh-water *Tritons,* or newts, the full-grown animal retains the long larval tail; but the long-tailed aquatic tadpole of the frog is gradually transformed into a tailless air-breathing animal, exhibiting probably the highest form of reptilian structure.

The Solenhofen bird furnishes a fresh exemplification of Von Baer's law of archetypal forms,* and illustrates in a very striking manner that essential similarity of anatomical structure in all animals, which is, perhaps, the most convincing evidence of unity of creative design that can be presented to our minds.

But we must not dwell upon this inviting subject, having to speak of those singular extinct creatures—*reptiles* in all their

* *Taylor's Scientific Memoirs,* 1853.

characteristics except the possession of the means of aërial locomotion—the Pterodactyles.

Amongst the *Vertebrata* the power of flight was formerly considered to belong especially and almost exclusively to birds. In the auks and penguins, however, we find birds whose wings are useless for flight, but serve admirably for swimming; and the ostrich, cassowary, emu, apteryx, etc., have *no wings* (properly so called) at all.

We are all familiar with the Mammalian type of flying animals, the bats, in which the finger-bones and membrane of the fore-hand are modified, so as to form organs fitted for the purposes of sustained and rapid flight. In the *Galeopithecus* and certain squirrels we have instances of other mammals imperfectly adapted for flight by a wide expansion of the skin on both sides of the body, from the neck to the hinder extremities, which serves as a parachute. Short flights are likewise performed by some fishes (as the *Dactylopterus*, for instance), which have their pectoral fins enormously enlarged, and capable of sustaining the body for a brief interval when they leap out of the water into the air; but their respiratory arrangements preclude a long absence from their native element.

In the Reptilian class we also have an illustration of imperfect flight in the little *Draco volans*, a lizard, which has an expanded membrane on each side of its body, and supported by the horizontal extension of the first six pairs of false ribs. It is, however, incapable of motion, and only sufficient to buoy up the creature in springing from bough to bough in pursuit of insects. That this capability of flight, which attains its highest development in birds whose respiration and circulation is the most active of all "warm-blooded" animals, should be assumed by certain mammals may seem remarkable, but that we should discover it exercised in a high degree of perfection among reptiles—a class so sluggish in the respiratory functions that they have been designated "cold-blooded"—seems at first incredible; indeed, the fossil remains of these curious creatures when first discovered gave rise to the wildest speculations. In 1784, Collini, an eminent German naturalist, attributed them to *Unbekanntes Seethier* (*unknown sea-beasts*); Hermann, to a creature "between a mammal and a bird;" Blumenbach, to a "water-bird;" Spix, to a species of vampire bat.

It is to the illustrious author of the *Ossemens Fossiles* that we are indebted for the first true determination of the place in nature which these flying Saurians held. It was Cuvier who, in 1801, described the "Reptile volant" from the lithographic stone, and in 1809* he gave it the appropriate

* *Ann. du Museum*, xiii. p. 424, t. 31.

XUM

PTERODACTYLES, FROM THE LITHOGRAPHIC LIMESTONE.

name of "Pterodactyle" (*wing-finger*), by which the group of extinct winged lizards is still called.

Although by far the most perfect specimens of the order *Pterosauria* have hitherto been obtained from the Upper Oolite of Germany, its remains occur in various strata from the Upper Keuper to the Chalk—proving its existence through that great period of geological time represented by the entire Secondary rocks—and in many localities both in this country and in Germany.

Both the examples figured in the accompanying woodcut are from the Lithographic Limestone near Eichstatt, in Bavaria, and are selected as illustrating two extreme forms of Pterodactyles in structure and size from that place. Fig. 1 is among the most perfect, as well as the smallest specimen known—*P. brevirostris*, Sömm., and also nearly the first discovered species. It is represented of the *natural size!**

Fig. 2 is the almost perfect skeleton of *Rhamphorhynchus Gemmingii*, Meyer, reduced to one-third the natural size (t.ix. f. 1), from H. Von Meyer's magnificent work on the Reptiles of the Lithographic Stone of Germany and France, containing twenty-one double folio plates, published in 1860. This specimen was discovered in 1854. Fig. 3 is a conjectural restoration of fig. 2.

The specimens of *Rhamphorhynchus* in the British Museum consist of one, in which the lower jaw, the long wing-fingers, and the hind limbs attached to the pelvis, with the perfect tail, are beautifully exhibited; and a larger individual, having the head, tail, fingers, and both feet very well preserved. Numerous *portions* of Pterodactyles have been found in Germany and elsewhere, but the two first discovered, *P. longirostris*† and *P. crassirostris*,‡ Goldf., being almost entire skeletons, may still be considered among the most important specimens. We have in the National Collection casts of both these, besides the actual remains of Pterodactyles from the Lias of Lyme Regis, the Stonesfield Slate and Cambridge Greensand, etc., and those lately acquired from Solenhofen, and it is to be hoped we shall have, when sufficient space is allotted for Palæontology, copies of all the remarkable specimens of this class which can be procured. Without entering unnecessarily into anatomical details, we can easily perceive many striking peculiarities of structure in the skeletons before us. The dissimilarity of the skulls of figs. 1 and 2 is very noticeable, and may be regarded as indicative of differences of habit in respect of food, and the method of obtaining it, as is the

* Sömmerring, Munich Acad., 1820. Cuvier, *Oss. Foss.*, 1836, pl. 251, f. 7. Buckland's *Bridgewater Treatise*, vol. ii, pl. 22, f. O.

† Cuvier, *Oss. Foss.*, p. 359, t. 23. f. 1.

‡ Goldfuss, in *Leopold Akad.*, xv. p. 63, t. 7—9.

case with analogous modifications in the form and strength of the beaks of birds, and in the jaws and teeth of animals.

Professor Owen* suggests that *P. brevirostris* and another species (*P. Meyeri*) were probably immature Pterodactyles, as they show the large cranium, short jaws, and unossified sternum, characteristic of the early period of life in crocodiles of the present day.†

But we find in this order such singular modifications, both in the dentition and the form and length of the jaws, as to lead to the supposition that it might include (like the Bats) genera with insectivorous, carnivorous, and possibly even frugivorous habits. The head, however, has always a more or less elongated form, and is lightened by large vacuities interposed between the nostril and the orbit. The vertebræ of the neck are about seven in number, and united by ball and socket joints, the hollow being in front. In almost all known specimens the neck vertebræ are the *largest*, and the entire series gradually diminishes to the sacrum, and terminates with a more or less long and slender tail.

The fore-arm consists of a short humerus, a radius and ulna of nearly equal size, and placed closely together; carpal and metacarpal bones, supporting four fingers, armed with claws, and a fifth or outermost digit (consisting of four joints), which is elongated like the four digits in the bat, and serves to sustain the membranous wing upon which the animal was upborne in flight.

The head of the humerus was supported by the union of the coracoid and scapula; and although the *furculum*, or "merry-thought" (so characteristic a bone in birds), is absent, we often find the sternum more or less perfectly preserved, and furnished with a very deep keel for the attachment of strong pectoral muscles by which the expansive wings of the Pterodactyle were moved.

"It is almost superfluous to remark that the evidence of the fore limbs had shown the Pterodactyle to have been a flying animal long before anything was precisely known as to its sternum. The development of the keel of the sternum in the Pterodactyle exceeds that of any of the bat tribe; and it may be confidently concluded that the flight of the winged reptile might have been at least as swift and of as long continuance as in the *Pteropi*. But, viewing the lightness of the bones of the Pterodactyle, and the relatively greater development of the interpectoral crest of the sternum, Professor Owen‡ believes it to have been a creature of more extensive, continuous, and power-

* *Palæontology*, second edition, 1861, p. 274.
† Gray, *On Skulls of Young Garhial and Crocodile*. British Association, 1862.
‡ Palæontl. Society, Suppt. No. iii., *Fossil Reptilia Cretaceous Formation*, p. 11.

ful flight than is now enjoyed by any bat; and the Pterodactyles may at least have been as capable of migration as the great frugiverous *Chiroptera*.

"The structural affinities, however, of the Pterodactyles to the cold-blooded air-breathers, and their analogy in wing structure to the bats, indicate that they might have possessed the faculty of becoming torpid, and of so existing during a period when their food in a given locality was not attainable."

In the smaller species (as fig. 1) the weakness of the posterior extremities is less apparent, but in larger ones (as fig. 2) the increase in length of the fore-arms is not followed by a proportionate strengthening of the hind limbs; on the contrary, they seem to become attenuated as if from disuse. The pelvis in Pterodactyles is very feeble, and (as in recent sauria) seems to be anchylosed to not more than three sacral vertebræ.

The leg is composed of femur and tibia (with traces of a fibula?). The tarsus can also be made out in some specimens. The hind foot seems composed, in some species, of four toes only, not five,* supported upon long and slender metatarsals, and numbering 1, 2, 3, and 4 joints respectively, as in the digits of the forehand.

In *Rhamphorhynchus* (fig. 2) the false ribs are extended as if for the attachment of the wing membrane, for which the feeble pelvis and hind limbs seem but ill adapted.

We have presented to us in this genus probably the most remarkable form of all the Pterodactyles, one furnished with a long *stiff tail*, exceeding the entire length of its body. It is impossible to examine this singular prolongation of the caudal vertebræ, which is embedded in a compact mass of minute ossified fibres (as shown in our figure of the natural size), without being at once impressed with the conviction that its use was analogous to the long tail-feathers of the frigate bird, acting not only as a powerful rudder (especially if it was furnished with a crested fold of membrane, as in the tails of many recent sauria), but also as an equipoise to the long and pointed wings, which in life must have measured more than four feet from tip to tip. The *Rhamphorhynchus*, when seated with closely folded wings, would probably have presented a very similar appearance with that of this ocean wanderer.

Beside the tiny Pterodactyle (fig. 1) there is another almost equally small (*P. Meyeri*), which, amongst other interesting characteristics, possesses the circle of sclerotic eye-plates. These bony plates occur in certain other reptilia, as the *Enaliosauria*, or sea lizards, and in turtles; and are also found in many birds. Their use appears to be "to vary the sphere of distinct vision,

* In the restoration given of *P. crassirostris* by Goldfuss in *Akad. der Wiss* (*loc. cit.*) he attributes five toes to the hind limb.

in order to descry their prey at long or short distances. These bony plates also assist to maintain the prominent position of the front of the eye, which is so remarkable in birds."*

The oldest known Pterodactylous remains appear to have been obtained from the Upper Keuper of Wurtemberg, but they are of only a fragmentary nature. The *Dimorphodon (Pterodactylus) macronyx*, Buckld., from the Lias of Lyme-Regis, is the oldest found in this country. In this species there is an unusual provision for giving support and movement to a large head at the extremity of a long neck, by the occurrence of bony tendons running parallel to the cervical vertebræ, like the tendons that pass along the backs of many birds, and those figured in the tail of *Rhamphorhynchus*. The expanse of the wings of this creature equalled those of the *Rhamphorhynchus*, but its jaws were eight inches long, and it is not supposed to have had a long tail. Beside a few large, long, and sharp-pointed teeth at the fore part of the jaws, it was furnished with a close-set row of short, compressed, very small, lancet-shaped teeth.

Fragmentary remains of Pterodactyles also occur in the Stonesfield slate of this country (one of the Oolitic series), and there is evidence of the existence of the same genus in the Wealden strata, but the species must have been of a larger size.

It is in the cretaceous series of England that the most gigantic specimens of flying lizards have been met with.

We are indebted to Lucas Barrett, Esq., F.G.S., the present director of the Geological Survey of the West Indies, and Jas. Carter, Esq., M.R.C.S., of Cambridge, for the discovery of remains of Pterodactyles in the Cambridge Greensand.

These bones, which always occur detached and much broken and water-worn, present, in the restorations of Professor Owen, proportions so gigantic that I cannot do better than quote his own calculations upon the subject, extracted from No. 1 Supplement to Palæontological Society's Memoirs for 1859, "Fossil Reptilia of Cretaceous Formation."

Dimensions of *Pterodactylus Sedgwickii*, Owen, Greensand, Cambridge:—

	Feet.	Inches.
"Humerus	1	0
Radius	1	4
Metacarpus	1	8
1st Phalanx	2	3
2nd ,, ...	1	9
3rd ,, ...	1	5
4th ,, ...	1	1
Total of one wing .	10	6

* Yarrel *On the Anatomy of Birds of Prey. Zool. Journal*, vol. iii., p. 181.

"Supposing the breadth of the Pterodactyle between the two shoulder-joints to be eight inches, and allowing two inches for the carpus and the cartilages of the joints of the different bones in each wing, we may then calculate that a large *P. Sedgwickii* would be upborne on an expanse of wings not less than 22 feet from tip to tip."

In the Palæontographical Society's Publications, Supplement No. 3, already referred to, Professor Owen says, "I am now enabled to adduce, from more recently acquired additions to the Woodwardian Museum at Cambridge, evidences of a much larger Pterodactyle, distinct from any previously known, and which must have acquired at least double the dimensions of *P. Sedgwickii*."

Professor Owen describes and figures remains of two other species of chalk Pterodactyles, *P. Cuvieri* and *P. compressirostris*, larger than *P. giganteus* of Bowerbank. This, however, still belongs to the race of the giants.

Evidence of a long tail in the Chalk species has not yet been met with; but from the number of detached caudal vertebræ found in the Cambridge Greensand, Professor Owen believes the *P. Sedgwickii* "had a long but moveable tail."

When looking at the skeleton of the Pterodactyle one is apt to fancy, for an instant, "here is a reptile trying to become a bird;" and the first glance at the *Archæopteryx* might suggest the notion that *here* it had succeeded in the attempt; but a more careful consideration of the subject will not fail to convince us that the Pterodactyle bird and bat are no less essentially members of distinct classes of animals because they are gifted with the common faculty of flight.

Thirty-seven species of flying lizards are known and described; how many individuals have been discovered it is impossible to say. There is every reason, however, to believe, from the frequent occurrence of their remains, that they were very abundant in the Mesozoic period.

We are not justified, however, in considering that they *altogether* took the place of birds; on the contrary, the discovery of the *Archæopteryx* proves them to have been contemporaneous races so far back as the upper Oolitic age.

All the mammals we are acquainted with in rocks of the Secondary period belonged to small animals obscurely resembling the lowest of existing quadrupeds. Their place in nature appears to have been filled by orders of reptiles, some of them now extinct. The gigantic Dinosaurians represented the land quadrupeds; Enaliosaurians took the place of whales, and the Pterodactyles of bats, and *partially* of birds, thus realizing Dr. Mantell's vision of an "Age of Reptiles."

PERUVIAN-BARK TREES AND THEIR TRANSPLANTATION.

BY BERTHOLD SEEMANN, F.L.S., F.R.G.S.

MANY years before the Irish famine William Cobbett predicted that calamity, and many years before the present cotton distress, far-seeing minds foretold that catastrophe. Nothing could be more sound than the principles upon which these unheeded warnings were based—the uncertainty always attendant on a *single source of supply*. Cobbett knew that potatoes, like all other organisms, are subject to occasional attacks of diseases and wide-spread epidemics; and that a whole people, like the Irish, relying for their staple food upon these roots, must sooner or later share the fate of the product upon which they have placed their main dependence, and with the fortunes of which they have intimately associated themselves. It was the same with cotton. Far-seeing men could perceive the political thunderstorm gathering in the United States; and knowing that all Lancashire, all England —in fact, all the world—relied upon this one source of supply for cotton, they denounced the recklessness of such improvidence in the strongest terms, formed associations for obtaining the raw material from other countries than the United States, and in speech and print did all in their power to arouse public attention. Yet as long as the mills were busy, and millions of bales were coming in without interruption, no notice was taken of their endeavours to stave off the fearful doom to which our manufacturing population was drifting. Now that the calamity has at length overtaken us, and thousands upon thousands of pounds are spent in keeping the workpeople from actual starvation, everybody remembers hearing Cassandra's voice. If but a hundredth part of what is now required to feed the hungry spinners had been devoted to encouraging the growth of cotton in the various tropical and subtropical possessions of Great Britain, Lancashire distress would never have been heard of, and manufacturers would have gradually relied upon the produce of free labour instead of paying a premium to slavery.

Mankind is threatened by a third danger, which may prove equally great, equally fatal in its consequences. Most men are probably not aware of the vast benefits they owe to the discovery of the Peruvian bark, the produce of various species of *Chinchona*, and the alkaloids, quinine and chinchonine, embedded in it. History takes no notice of the death of countless mediocrities from fever and ague, but fails not to record that Alexander the Great died of the common remittent

fever at Babylon, and that Oliver Cromwell was carried off by ague. A few doses of quinine might have saved their lives, and compelled Clio to make very different entries in her diary than she has done. The whole Walcheren expedition was saved from destruction by a Yankee skipper arriving just in the nick of time with a supply of this medicine. In order to hold many important tropical possessions it is not only necessary for our race to keep the powder dry, but also take care not to let the quinine run too low. In fact the drug is almost as indispensable to mankind as air itself, and aided by this silent agent Europeans have been able to establish happy homes, busy factories, and flourishing colonies in districts which, without this invaluable aid, would have simply become their graveyards. Our only wonder is how we could ever have done without it, and what would become of us if the supply should ever fail. And the supply does begin to fail, fail rapidly. It is known that 1,200,000 lbs. of Peruvian bark (meaning by that term all medicinal barks produced by Chinchona trees) are annually imported into England; and it is estimated that no less than 3,000,000 lbs., and probably a much greater quantity, are consumed every year throughout the world. The demand is daily increasing, and the drain upon the South American forests, including those of New Granada, Ecuador, Peru, and Bolivia, has now been going on for more than two centuries, though not to such an extent as at present. The better kinds, those yielding the largest quantity of alkaloids, are very local in their geographical range at present, often limited to very circumscribed districts; and though we speak of Chinchona forests, it is absolute delusion to fancy that these trees, like our pines and oaks, form entire woods by themselves. On the contrary, they are intermingled with other trees, and generally occur in isolated specimens. The bark is collected by ignorant Indians, who, improvident of the future, strip the tree anyhow, and in most instances without properly felling it, so that it begins to rot after being robbed of its produce, and has no power to put forth new shoots from the root. Thus, what with the excessive and unceasing demand for bark, and the reckless manner of collecting it, large tracts of country, formerly famous for their abundant yield, are now entirely denuded of almost every trace of Chinchona vegetation. The neighbourhood of Loxa in Ecuador was at no very remote period one of the principal localities for several of our best barks; but when, in 1847, Captain Pim and I visited the place, we had to go a considerable distance from the town before we obtained even the sight of a single specimen. Stimulated by the present high prices the bark collectors have penetrated the remotest districts, explored wilds probably

never trodden by the foot of the white man; and if by any chance they are lost, or their provisions fall short, death is their inevitable doom. Dr. Weddell describes a poor fellow who thus had ended his days, far away from home and friends. His corpse was nearly naked, and covered with myriads of insects, the stings of which had tormented his last moments. Close by was a hastily-constructed hut, his clothes, his knife, and an earthen pot, showing the remnants of the last meal of a man in search of medicine which was to save the life of others.

The Indians, though at present the best *cascarilleros,* or bark collectors, and intimately acquainted with the names and commercial value of the different sorts, are supposed by some to have been formerly ignorant of the great therapeutic qualities of these drugs. They called the Loxa bark "Quinaquina" (bark of barks); and Markham has well shown that in the Quichua language, to which the term belongs, a doubling of a name is an indication that the plant to which it applies possesses, in the estimation of the Indians, some medicinal virtue. Now, we know of no other use of the Loxa bark except that derived from its febrifuge properties, and in my mind there is little doubt that it was to this the doubling of the name must be attributed. Those who have had practical experience in gathering information about medicinal plants from the lips of barbarous people, as I have had, will not be surprised at the secresy with which the knowledge of the use of Quinaquina was preserved. As a rule, the most sovereign remedies are never revealed to a stranger, nor known to the people at large, and no bribe will induce the "medical profession" amongst the Indians to be otherwise than reserved when questioned by Europeans. Madame de Genlis, in her "Zuma," builds the plot of her charming little story on a conspiracy of the Indians, the object of which was to allow the climate to destroy their Spanish enemy by withholding the knowledge of the bark when fever attacked them. I am aware that this is not history, but I have always thought, considering the Indian character, and the strong desire of the aboriginal population to get rid of their foreign oppressors, that Madame de Genlis had here hit upon the true solution of the question why so many years elapsed before Europeans became acquainted with this bark of barks.

It is not until the year 1630, that Don Juan Lopez de Canizares, the Spanish Corregidor of Loxa, being ill of intermittent fever, an Indian is said to have revealed to him the virtues of the bark, and instructed him in the proper way of administering it. About eight years later the wife of the fourth Count of Chinchon, Viceroy of Peru, was suffering from the

same complaint, when the Loxa Corregidor forwarded a parcel of powdered quinaquina as a sovereign and never-failing remedy for "tertiana." It effected a complete cure, and the particular plant which had this honour, and yields the true and original Peruvian bark is, as Howard justly concludes, the *Chahuarguera* variety of *Chinchona Condaminea*, a kind containing a large percentage of *Chinchonidine* (the importance of which is just beginning to be recognized). It is therefore not to quinine,

CHINCHONA CONDAMINEA, VAR. CHAHUARGUERA (*reduced one-half*).

but to *Chinchonidine* that the countess's cure was due. That lady on returning to Spain in 1640, took with her a quantity of the healing bark, and was thus the first to introduce this invaluable medicine into Europe. Hence it was sometimes called Countess's bark, or Countess's powder; and hence, to commemorate the event, Linnæus named the genus of plants producing these barks, *Chinchona*. By some accident, not isolated in his nomenclature, he mis-spelt the name, writing

Cinchona, and until a recent period no attempt was made to correct it.

The Jesuits in their wanderings through South America became well acquainted with bark, and in 1670 they sent parcels of it to Rome, whence it was distributed by Cardinal de Lugo amongst the members of their society throughout Europe, and obtained the name of Jesuit's bark, or Cardinal's bark. It was in consequence of this patronage that bigoted Protestants refused to avail themselves of a medicine favoured by the Roman Catholics, just as staunch Catholics objected to the use of beer, an infusion of barley flavoured with hop, instead of sweet gale, and other herbs, as in the case of *ale*, because, as an old song has it, "with this same beer came in heresy here." At the time of Cromwell's death from ague, the use of Peruvian bark was actually known in London. In 1678 Louis XIV. bought the secret of preparing quinaquina from Sir Robert Talbot, an English physician, for two thousand louis d'ors, a title, and a large pension, and from that time downwards, the use of this medicine, though often and violently opposed by practitioners, gradually made its way into every country and all circles of society. The only people who now entertain any prejudice against its administration are the natives of those very countries from which we obtain our supplies. The medical men of Guayaquil, for instance, must call it by some other name in their prescriptions, or else patients object to taking it. The Spanish people throughout America have a deeply-rooted theory that all diseases are referable to the influence of either heat or cold, and, confounding cause and effect, they pronounce all fevers to proceed from heat. Bark they justly believe to be very heating, and hence their prejudice against its application in fever—a prejudice which seems to have communicated itself even to the Indians.

Until the present century Peruvian bark was administered in its crude state; and it was not until 1816 that a Portuguese surgeon, Dr. Gomez, succeeded in isolating the febrifugal principle, hinted at by Dr. Duncan at Edinburgh, and named by the former Chinchonine. But the final discovery of quinine is due to two French chemists, Pelletier and Caventou, in 1820, who considered it a vegetable alkaloid analogous to morphine and strychnine, and they afterwards found that the febrifugal principle was seated in two alkaloids, quinine and chinchonine, separate or together. In 1829 Pelletier discovered a third alkaloid, aricine, derived from *Chinchona pubescens*, and at present of no known medicinal value. The different organic constituents of *Chinchona* bark are :—

Quina . .	Kinovic acid.
Chinchonia .	Chinchona red.

Aricina . .	A yellow colouring matter.
Quinidia . .	A green fatty matter.
Chinchonidia .	Starch.
Quinic acid .	Gum.
Tannic acid .	Lignin.

Quinine is a white substance, without smell, bitter, fusible, crystallized, with the property of left-handed rotatory polarization. The salts of quinine are soluble in water, alcohol, and ether. Chinchonidine differs from quinine in being less soluble in water, altogether insoluble in ether, and having the property of right-handed rotatory polarization, agreeing in the latter respect with quininine, a substance which forms salts like those of quinine, and becomes green by successive additions of chlorine and ammonia. In this changing of colour it differs essentially from chinchonidine, which has not the property of turning green, and forms a sulphate almost exactly like that of quinine.

In many distant parts quinine is equal in value to gold, and there is hardly a chemist of eminence who has not tried his hand at producing these alkaloids artificially. We have of late years obtained so many wonderful results in the laboratory that we should not treat their endeavours as aiming at any thing beyond their reach. There is just a possibility that one day the dreams of alchemists may be realized by the baser metals being converted into gold, and the artificial production of quinine ranks in the same category. But these alkaloids are such complex atoms that there is very little probability of their ever being obtained from any sources save Nature's own workshop. Such being the present aspect of this question, it becomes a matter of the highest interest to mankind that the even flow of their source should not be interrupted.

The genus *Chinchona* of Linnæus belongs to the Chinchonaceæ, the same natural order which embraces the Coffee, Ipecacuanha, and many other important productions. All the species, and there are a great number, are either trees or large shrubs, and their general aspect may be compared to our beech, whilst a flowering branch might be likened to that of a lilac. The bark is smooth, or in the older trees more or less rugged, often covered with various lichens, which at one time were thought to be excellent marks for distinguishing the different sorts of barks, but which are now accounted of little value in pharmacological determination. The wood is at first white, but afterwards assumes a yellowish tinge; it is of beautiful grain, and takes a ready polish. The leaves are opposite, entire, either glabrous, or more or less covered with hair, and on the under side, in the axils of the veins, either covered with *scrobiculæ* or destitute of them. A theory had gained ground that the absence of these *scrobiculæ* proved the worthlessness

of a species for all febrifugal purposes, but this theory has of late been demolished, some utterly worthless species having *scrobiculæ*, and some really valuable ones, for instance, *Chinchona succirubra*, the Red bark, not having them. The petiole is rather long, and supported by stipules. The flowers, arranged in cymose panicles, are white, pink, or purple, and often sweetly scented. The calyx is five-toothed. The corolla hypocrateriform, five-lobed, and having inside five stamens. The capsule is ovate, oblong, or linear-lanceolate, crowned with the remnant of the calyx—two-celled, many-seeded and opening from the base to the apex. This latter technicality was first pointed out by Linnæus in his tenth edition of his *Genera Plantarum;* but in consequence of information, probably received from Mutis of Bogota, that the capsules opened sometimes from the top to the base, as well as from the base to the top, the character was disregarded until restored by Endlicher and Klotzsch; Dr. Karsten has called its validity once more in question, but many botanists are inclined to think that the exceptional cases brought forward in support of his opinion may be explained away by regarding them as the result of mechanical, rather than organic dehiscence. Commercially, this technical point (by which Chinchonas principally differ from Ladenbergias) is of the utmost value, as all the Chinchonaceous plants, the capsules of which open from the apex to the base, may, in a practical point of view, according to Howard's investigation, be considered as not producing alkaloids. The seeds are flat, winged, and so light that one would fancy that a breath of wind could disperse them over large tracts of country, and that by means of these peculiarities the different species of *Chinchona* enjoyed a very wide geographical range, while exactly the contrary is the case, all the species being extremely local.

The Chinchona trees range from the 19th degree of S. to the 10th degree of N. latitude, following the almost semicircular curve of the Cordillera of the Andes over 1740 miles of latitude. The most favourable conditions of their growth are, as Markham has summed them up, a continuous vegetation, a mean temperature, varying according to species, from 60° to 70° Fahr., an almost constant supply of moisture, and an elevation of from 5000 to 8000 ft.; some species, however, descending below 2500, and some ascending to 9000 ft. Their favourite haunts are ravines and valleys, or slopes of mountains. There they grow, surrounded by the most magnificent scenery in the world, midst tree-ferns, arborescent passion-flowers, *Melastomaceæ*, and allied Chinchonaceous genera.

There are five principal regions from which our present supply of bark is derived, viz., the New Granada region, the Red-bark region on the western slopes of Chimborazo, the

Crown-bark region in the province of Loxa (Ecuador), the Grey-bark region of Huanuco in Northern Peru, and the Calisaya region in Southern Peru and Bolivia. The species inhabiting most of these regions have lately been studied with more than usual accuracy and minuteness. Those of New Granada have been investigated for many years by Mr. Lindig, and the results have been made known by Dr. Karsten in his *Flora Columbiana*. The Red-bark region has been visited by Messrs. Spruce and Cross, both of whom wrote excellent reports on it. Southern Ecuador and Northern Peru have been most ably handled by Mr. J. E. Howard in his *Illustrations of the Nueva Quinologia of Pavon*, a work originally embracing some of the results of the Spanish expedition to South America under Ruiz, Pavon, and Tafalla, but left unpublished until Mr. Howard took them in hand, embellished them with splendid plates, and gave them to the world with a long series of annotations such as only a perfect master of the subject could supply. The Caravaya region in Bolivia and Southern Peru, first explored by Hænke, has lately been visited by Mr. Markham, whose investigations have been published in his *Travels in Peru and India*, a volume full of the latest and soundest information on everything connected with the history, conditions of growth, and cultivation of Chinchonas. Dr. Weddell, an English botanist, residing in France, had previously given us a monograph principally on the Bolivian species, which he has studied during his extensive travels in their native country. The literature relating to Chinchonas is an extremely rich one; even when, in 1826, Bergen published his monograph, his catalogue of all written on the subject extended over seventy-two pages, and included 670 different publications. Since then numberless additions have been made, but none of them exceed in value those of Karsten, Markham, Howard, and Weddell.

The constant drain for Chinchona bark upon South America has already been pointed out, and the exhaustion of the forests is proceeding at so rapid a rate that the utter annihilation of the trees, local as many species are, is merely a matter of time. Indeed, the days are fast approaching when the poor fever-stricken patient will sigh in vain for the only remedy that can afford a speedy and certain relief. The Republics in whose dominion Nature has placed these invaluable forests are too weak and ignorant to pass or enforce laws for their proper protection and administration, and too indolent to make plantations which would ensure our future supplies of bark. Under such circumstances German, Dutch, and English men of science—I shall not discuss the question of who was the first—have for years advocated the necessity of introducing the bark trees into the higher mountains of the East and West Indies,

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but for a long time their memoirs were shelved by men in office. In 1852, however, the Dutch government was induced by Mr. Pahud, then Minister of the Colonies, to send Dr. Hasskarl, a German botanist, to Peru in order to obtain seeds and plants of the Chinchonas for transplantation to the Upper mountains of Java. Unfortunately Dr. Hasskarl got hold of a species which he believed to be a valuable one, but which, after millions of it had been raised in Java, proved to be *Chinchona Pahudiana*, utterly useless for all practical purposes. The really valuable species the Dutch did not succeed, and have not succeeded to this day, in propagating to any extent, though under skilful treatment they may be multiplied rapidly, even the leaf-buds striking readily. But considering that the whole cultivation was necessarily an experiment, their progress was sufficiently encouraging to back the proposal which first Dr. Royle, and afterwards with better success of being accepted, Mr. Markham made to the British government to introduce the Chinchona trees to India, Ceylon, and Jamaica. In 1859 the Secretary of State for India charged Mr. Markham, who was thoroughly familiar with South America and the Spanish and Quichua languages, with the duty of superintending the introduction. The latter at once submitted a plan which, if carried out in its integrity, would have been productive of the best results. It was to send a competent botanist to every one of the five great Chinchona regions, and have a swift steamer on the coast of South America to receive the seeds and plants collected, and convey them direct to the East Indies, where about £40,000 are annually spent to purchase quinine for the troops and officials. A false system of economy induced the India office to withhold its sanction, not only to the exploration of the New Granada and Loxa regions, but also to the use of a steamer, the most important part of the whole plan. Messrs. Spruce and Cross undertook to forward the product of the Red-bark region, Mr. Pritchett those of the Huanuco district, whilst Mr. Markham himself penetrated into Caravaya, far beyond the boundaries of even Spanish civilization. Though the utmost secresy was observed, the real object of these explorations soon spread about, and the narrow-minded South American governments passed laws prohibiting the exportation of seeds or plants. Mr. Markham had just collected a sufficient number of the *Chinchona Calisaya* and other valuable species, when the jealousy of the municipal Juntas compelled him to beat a hasty retreat, and, avoiding the regular roads, make the best of his way over the frozen summits of the Cordilleras to the port of Islay.

Though Mr. Markham's well-conceived plan was but partially carried out, there are now fine plantations of Chinchonas, including the most valuable species, in the East Indies, Ceylon, and

Jamaica, and so rapid is their extension that, in all human probability, there will be a supply of Peruvian bark from these sources at the very time South American forests are approaching exhaustion. Other countries with climates suitable might try the cultivation, which, in order to be of real benefit to mankind, ought to be as general as that of the spices, and conducted by private enterprise. The first plantations in Java were made in the open clearings, but afterwards this system was given up, and avenues were cut through the virgin forest, in which the Chinchonas were set, thus going to the other extreme, and allowing them no sun whatever. The latter is the system still pursued in Java, whilst the former, with some modification, has been adopted on some of the most important plantations in India, and is expected to lead to more speedy and profitable results.

THE MOON.

BY THE REV. T. W. WEBB, F.R.A.S.

THE student who feels disposed to carry into effect the suggestions contained in a previous paper, will have to bear in mind that, notwithstanding the peculiar accessibility of our satellite in point of distance, its frequent visibility, and the powerful grasp upon it possessed even by moderate sized instruments, certain conditions are requisite for the accurate comprehension and delineation of its minute details; and not even keenness of sight, or accuracy of pencil, can adequately compensate for entire ignorance of perspective, or of the laws of light and shade. The surface which we have to interpret and represent may probably be composed of materials not dissimilar to those of our globe, and their arrangement is not so wholly different as might be supposed in the judgment of an uninstructed eye; but they are exhibited to us in a way so very unlike any views that we ever obtain of the surface on which we stand, that it requires some attention to discover their real configuration. We look upon a hemisphere which presents its details to us under every possible angle between 0° and 90°; and the partial or total concealment of one object behind another, and the effect technically called "foreshortening," by which length is contrasted when viewed end ways, and height diminished when regarded from above, and circles are transformed into ellipses, and right angles become obtuse or acute, ought to be understood and allowed for. A general idea also of what is termed "relief," is equally as important as one of perspective. The laws of light and

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shade produce effects the reason of which is not always apparent, except to the careful observer, and which are perhaps not always fully attended to, even by artists, who ought to be especially scrupulous in this respect, but which show their fullest development in the moon. There it is clearly seen how small a relation the actual amount of elevation bears to the extent of shadow which it occasions in the nearly horizontal illumination of the beginning or close of the lunar day, and how slight a resemblance there often is, under such circumstances, between the outline of the substance and the shadow. Every little insulated hillock will betray itself in this position by so disproportioned a shade, that Schröter considered that elevations of not more than eighty feet might thus be clearly distinguished near the "terminator," or general boundary of light and darkness, even at our distance of nearly a quarter of a million of miles. The shadow of a rounded summit will be projected out into a long spire, so sharpened at the point as to deceive the unwary spectator into the impression of its falling from a tapering pinnacle; inconsiderable ridges near the terminator will bring in great encroaching notches or bays of darkness; the rings of craters will increase strongly in apparent breadth; the long gentle slopes which usually incline upwards to the foot of the wall, like a broad "glacis," in military language, and pass unnoticed under a higher sun, being thrown up from the surrounding level to swell the general mass, while the interior cavity seems also to open wider as the lower slopes and terraces of its precipitous sides disappear one after another in the advancing shade. Nor are these more familiar appearances all that the observer will have to account for. He must seek in the same laws of illumination the explanation of less ordinary effects; he may find a tapering spire of shadow distorted from its regular outline by the uneven ground which it traverses, or squared off suddenly before reaching its termination, because it is traversed at right angles by a comparatively inconsiderable ridge; he may perceive that the shade cast by a peaked but broad-shouldered summit loses its sharpness with the advance of the lunar forenoon, and at length disappears, from becoming entangled among its own inferior buttresses, while these alone project a black outline of an entirely altered character upon the plain at their feet. The same results of the unchanging laws of illumination, it need not be said, occur equally upon the earth; but here we are little sensible of them. Surrounded by them, and enveloped in them, we are not in a position to comprehend their full proportions, or to judge intuitively how the relief of our landscape would appear in a bird's-eye view at the distance of a quarter of a million of miles. And besides this important difference, we can never

see in terrestrial effects those sharp and vehement contrasts of light and shade which strike us so much in the moon. The presence of a highly reflective atmosphere, even when unvaried by clouds, which diffuse much light, modifies the depth of our shadows, in proportion as it illuminates and colours what would otherwise be the blackness of our sky. On the moon that vaporous envelope is, if not altogether wanting, far too rare to produce any such result.

Here much general light is interwoven with our darkness, and the direct sunshine is not the only medium of illumination; air-tints and reflections soften all our shadows by day, and twilight encroaches far upon the regions of night: there (save only when the keen eye of Dawes, sheltered by his own contracted eye-piece, detects in the black interior of some colossal crater a feeble reverberation from its illuminated wall) everything not in direct sunshine is involved in absolute midnight. Half-tones, the cause of so much beauty upon the earth, do not exist upon the moon, excepting where a narrow dusky fringe along the terminator, or the fainter beam that first breaks in upon the floor of a crater, or touches some mountain's peak amidst the darkness of the night-side, shows that a portion of the solar disc alone is visible. But the student who has mastered these peculiar characteristics has still a task remaining—to allow for the difference of aspect introduced by what is called "libration." Were the moon to travel round us with a perfectly equable velocity, in an orbit coincident with the ecliptic, revolving at the same time on an axis perpendicular to its orbit, we should always see exactly the same hemisphere, with an invariable arrangement of the spots relatively to the centre and the edges of the disc; and precisely the same effects of light and shade would recur at corresponding periods in every lunation. But none of these conditions are fulfilled. The moon's orbit is an ellipse, a form necessarily involving inequality of speed in its different parts; and since her rotation upon her axis is perfectly equable, this alternate acceleration and retardation in her orbit, urging her beyond, or keeping her behind, the place in the sky which she would have occupied with an equable motion, has the effect of making her spots appear to "librate," or swing to and fro, alternately in advance of and behind their mean position. This motion from E. to W., and from W. to E., is called the "libration in longitude." The inclination of the moon's orbit to the ecliptic, and of her axis to her orbit, combine to produce another kind of libration, "in latitude," which shifts the spots in a similar way upwards and downwards; and as in the previous case we see alternately a little way round the mean E. or W. limb, so in this, we catch a little more of the regions beyond the arctic or antarctic pole.

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These changes, it is true, are of no great extent, never exceeding 7° 55′ from E. to W., or 6° 47′ from N. to S.,* and their influence is not important upon the central parts of the disc; but they keep the limb in an unsettled state, and are continually altering the perspective of the parts adjacent to it, so that in this situation a region will have an entirely different aspect at the same age of the moon in different lunations. The libration in latitude may also sometimes occasion a slight deviation in the direction of the shadows, which may not be unimportant in the case of objects lying E. and W., and assuming an altered appearance as the shadow falls on the N. or S. side. The larger features, indeed, are liable to no misapprehension, keeping, under all circumstances, their own determinate character; but as to minuter details, it would hardly be supposed, except from actual experience, how great an amount of apparent change may sometimes depend upon very small deviations in the angles of incident and reflected light. The landscape artist, however, who has delineated the same subject repeatedly from slightly altered points of view, and in the varying light of successive hours, will require no further or closer illustration of these transformations. Such are the difficulties which beset the study of the moon, though not without some degree of compensation, since, if these discrepancies at one time perplex us, at another time they unravel perplexities; and the play of light and shade which may occasionally bring a familiar object before us in "a questionable shape," will now and then clear up, beyond a question, the nature of one previously doubtful.

The subject will be resumed in a future number. A pressure on our space compels the postponement of our list of "Double Stars."

OCCULTATIONS.

There will be only four occultations during this month at convenient hours. Jan. 1st., κ^1 *Tauri*, 5½ mag. (one of the components of a wide double star) will disappear at 10h. 3m., and reappear at 11h. 8m.—Jan. 9th, 55 *Leonis*, 6 mag., occulted when the moon rises, will emerge at 10h. 12m.—Jan. 26th, 27 *Arietis*, 6 mag., will be hidden from 11h. 31m. till 12h. 8m.—Jan. 27th, δ *Arietis*, 4½ mag., will disappear at 5h. 10m., and reappear at 6h. 28m.

* These quantities are somewhat variously given; the value here adopted is from Beer and Mädler.

There is a third kind of libration called the *parallactic*, arising from the different position of the point of view upon the surface of the earth, and varying with the moon's altitude above the horizon, but it never exceeds 1° 1′ 30″.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

ROYAL ASTRONOMICAL SOCIETY.

At the first meeting of the present session, on the 14th Nov., the Astronomer Royal called attention to the efforts which have been lately made to improve our knowledge of the measure of the earth and of the heavens, his discourse being illustrated by a map showing the triangulation of Europe as it stands at present, and rendering evident that from the Danube to the North Cape on the N., and to Valentia on the W., very little is left to be desired.

Mindful of the past labours of the French and ourselves on the measures of arcs of *meridian*, the illustrious Struve, the originator of the recent operations, suggested that an arc of *parallel* should be measured, extending from Valentia, using the present triangulation as far as it reaches, and extending it to the town of Orsk, on the Oural, thus comprising nearly seventy degrees of longitude, an arc of such a length, that, as remarked by the Astronomer Royal, it is scarcely probable that a longer will ever be measured by man.

For the measure of the earth, then, it was first necessary to find by some lineal measure *the length of this arc;* in other words, to find the distance in yards (our standard of measurement) between Valentia and Orsk; and secondly to find the *difference in time* between the two places.

First, as to the length of the arc. The British part of it required little attention, as thanks to the admirable work of our Ordnance surveyors, and subsequent investigations by means of chronometers, the actual distance from Valentia to Dover is known to within a few yards.

Unfortunately the continuation of this line to Paris, which has been effected with equal accuracy, dips too much to the south to be available for the present purpose. It became necessary, therefore, to effect a junction between Dover and Belgium to fill up the gap that there exists between the English and continental systems of triangulation. This has been admirably done by Sir H. James during the present year, and the whole distance from Valentia to some point pretty well advanced, is by this time computed, while the triangulation itself is fast progressing towards Orsk.

Secondly, as to the difference of local time at the extremities of this arc. This must be determined from those observed at intermediate places on the arc; as, for instance, between Valentia and Greenwich, and Greenwich and Brussels, and in this determination telegraphs and railways will be freely used. A complete circuit between the first-named points were placed at Mr. Airy's disposal by Sir Charles Bright, after the Atlantic cable (which "took sea" at Valentia) proved a failure. The difference of time obtained by the electric current (which took 1-10th of a second to traverse the 800 miles of wire) agreed exactly with that formerly derived from the transit of chronometers between the two places.

The recent experiments of Foucault with the turning mirror, and the parallax observations of the planet Mars which have been made during the past three months in both N. and S. hemispheres, were alluded to, as bearing upon the distance of the sun, which is the basis of all measures of the heavens.

The smaller velocity of light deduced by Foucault, linked to the sun's distance by its aberration, was shown to be supported by some of M. le Verrier's recent investigations, while the extreme doubtfulness of some of the most important observations of the transit of Venus on 1769, on which the received distance of the sun depends, renders the success of the observations of Mars doubly desirable. And although the distance of Mars, and not of the sun, will, in the first instance, be obtained by this method, they are bound together by a proportion which has been accurately known since the days of Copernicus and Tycho.

Professor Selwyn communicated a note relative to an apparent notch in the sun's limb, observed by him some little time ago. From the note we learn that he now ascribes the appearance to the low power employed, as the complete limb was observed on the same day by the Rev. W. R. Dawes, in his larger instrument.

Several other papers, among them a valuable one on eye-pieces, by the distinguished observer we have just named, and on the diameters of Mars, by the Rev. R. Main, were communicated to the Society.

The latter paper was accompanied by some drawings of Mars, from observations made in the Oxford heliometer. Another series of thirteen drawings, chosen from twenty-five made during the past opposition of the planet, and embracing a complete rotation, was exhibited by Mr. Lockyer.

This latter series, the result of observations made by an equatoreally mounted refractor of $6\frac{1}{4}$ inches aperture, the workmanship of Messrs. Cooke and Sons, of York, was remarkable not only on account of the details of the planet shown, but also of the exact agreement of the broad features of the drawings with a similar series taken by Beer and Mädler, in 1830.

CHEMICAL SOCIETY, *December 4th.*

Recent Formation of Rocks.—A paper was read by Mr. A. H. Church on "Certain Processes of Rock Formation now in Action." The author's attention was directed in the summer of 1860 to an instance, at Bude-Haven, in Cornwall, of the consolidation of sea-sand by means of land-springs, and he endeavoured to trace the chemical causes of the phenomenon. From numerous analyses of the loose and of the consolidated sand, and also of the water of the district, the author came to the conclusion that the cementing action was often due to the reprecipitation, between the sandy particles of carbonate of lime—this substance being originally derived from the shelly *débris* of the sand itself, and being held in temporary solution by carbonated water. The absence of marine salts from the consolidated sand supports this hypothesis. Mr.

Church then proceeded to describe the formation of travertine in several localities in England, noting more especially the rapidity of the process, the organic substances, occurring sometimes most abundantly, in the deposits, and the physical characteristics of the formation. As to this last point, the author pointed out the remarkable similarity in construction between the discoidal concretions of carbonate of lime in travertine and Rainey's globular lime-crystals, pearls, and the minerals pisolite and oolite.

The latter portion of the paper was partly devoted to a brief notice of the consolidation of various materials into rocky or mineral substances by means of silica, oxide of iron, etc., and partly to the peculiar processes by which certain mineral and metallic veins are gradually formed by the elimination of the constituents from the surrounding masses of mixed matters. Mr. Church noticed the construction of the geodes of iron-ore, containing nuclei of ochre or clay, found in the ochre pit on Shotover Hill, near Oxford; the formation still going on* of magnesiam limestone at the upper part of Bullingdon Marsh, in the same neighbourhood; the occurrence in clay of calcareous concretions, and in chalk of silicious nodules; and the production, at the present time, in the chalk, of such minerals as allophane and collyrite, in which forms much of the silica and alumina† of the chalk becomes, as it were, concentrated.

In the interesting discussion which followed, Mr. Church supported his views of the modern formation of silicious minerals by the case of the silicified basket of eggs found in an abandoned chalk-pit, near Winchester, many years ago.

CHEMICAL SOCIETY.—*December* 18.

Artificially Formed Alcohols.—A communication was read from Professor Wurtz, in which he pointed out, among other novel facts, certain hitherto unobserved differences between ordinary alcohols as obtained by fermentation, and those artificially produced by synthesis from the corresponding olefiant. The former may be viewed as water in which one equivalent of hydrogen has been replaced by ethyle, or its homologues, the latter as water plus ethylene or other olefiants. This is shown by the formulæ

$$\left.\begin{matrix} C_{10}\ H_{11} \\ H \end{matrix}\right\} O_2 \qquad \text{Normal amylic alcohol.}$$

$$C_{10}\ H_{10},\ H_2\ O_2 \qquad \text{Amylic alcohol formed by synthesis from amylene.}$$

Chinoline Blue.—Dr. Hofmann gave a most interesting oral account to the Society of his experiments on the constitution of this beautiful but fugitive dye, discovered some years ago by Greville Williams. A prize of 20,000 francs has been recently offered in France to any one who will devise a way of rendering this dye permanent, and the material is now manufactured on a

* This modern deposit has been worked for magnesia commercially.

† Mr. Church displayed numerous illustrative specimens of the products referred to, including crystals of sulphate of lime, and of sulphate of baryta, found in septaria, in the London clay.

large scale in Paris. It occurs in magnificent square prismatic crystals of brilliant metallic lustre, and which, if made from pure chinoline (C_{18} H_7 N) by the successive action of iodide of amyle (C_{10} H_{11} J) and potash (KO, HO), have the constitution expressed by the formula—

$$C_{56}\ H_{35}\ N_2\ I.$$

This substance contains the elements of two equivalents of chinoline—one of iodide of amyle, and one of amylene. It yields a magnificent series of salts. Analogous substances may also be obtained by taking lepidine (C_{20} H_9 N) instead of chinoline, and iodide of ethyle instead of the amyle compound.

LINNEAN SOCIETY.—*December 18th.*

The first paper read was by Mr. A. H. Church, "On the Form of the Vascular Fasciculi in certain British Ferns." The author pointed out the general characteristics of the vascular bundles in the majority of the British species of Lastrea, noting two remarkable exceptions in *L. oreopteris*, the mountain fern, and *L. thelypteris*, the marsh fern. In these latter plants there are only two vascular fasciculi in the stipes of the frond, and these ultimately unite. The scalariform ducts are arranged in these two species in the form of the Greek letter Σ, while in other Lastreas the prevalent form is that of an oval with a small incurved process. Mr. Church pointed out the vascular arrangement in several other British species as compared with certain foreign forms and British varieties, having derived his conclusions from several hundred examinations of the living plants. In these researches he made use of perchloride of iron, which revealed the secondary deposits and ducts containing tannin, by striking a blue-black colour with them.

ROYAL GEOGRAPHICAL SOCIETY.—*December 8th.*

Overland Route from Pekin.—Dr. Norton Shaw read a paper descriptive of Mr. Grant's important and adventurous overland journey from Pekin to European Russia. Mr. Grant, having obtained a passport for Mongolia from Prince Kung, started from Pekin on March 26th, 1862. On the 1st of April he arrived at Kalgan, the most important commercial town in the north of China. On the 9th of May he reached Ouga, the capital of Mongolia, having traversed the desert of Gobi entirely unattended. Remaining twenty days at Kiachta, he started for Irkutsk, the capital of Eastern Siberia. After stopping here for a short time, he set out for Tomsk, whence he took a steamer to Tumen, calling at Tobolsk, the ancient capital of Siberia, from whence he passed through Ekaterinburgh to the Ural Mountains, and arrived at Tagill, where there are valuable mines belonging to the Demidoff family. These mines last year gave employment to upwards of 60,000 persons.

Mr. Grant stated that by this route communication might be

made between London and Pekin in twenty-one days, the present route requiring upwards of fifty. He also praised most warmly the universal kindness and hospitality of the Russians.

Mr. LAY, the Chinese Commissioner, stated that an expedition was being organised in England to assist the Chinese government: Prince Kung having expressed a wish to avail himself of the assistance of Englishmen in suppressing the Taeping rebellion. This expedition is to be placed under the command of Captain Sherard Osborn. In connection with this movement it was proposed to organize a system of emigration, by which the surplus population of China could be located in some of the islands of the Indian Archipelago.

NOTES AND MEMORANDA.

MAGNETIC PERTURBATIONS AND AURORAS.—The epochs of the appearance of the Aurora borealis, and those of magnetic perturbations, coincide pretty closely. Rarely are auroras exhibited without magnetic disturbances occurring at the same time, and the agitation of the magnetic needle indicates the approach of an aurora. The causes of the two phenomena appear to operate simultaneously, and they are often accompanied by earthquakes in countries exposed to that class of action. Magnetic perturbations, however, operate over a much wider range than auroras.—*Quetelet, Physique du Globe.*

VEGETATION AND TEMPERATURE.—M. Quetelet says that careful observations have convinced him that a plant develops much more rapidly during a mean temperature, when this temperature varies, than when it is uniform, provided that it does not fall below freezing. He is also of opinion that the effect produced is equal to the squares of the temperatures. Thus, if the effect of an uniform temperature of 10° Cent. be considered as 100, that of an average or mean temperature equal to 10°, but varying between 6° and 14,° will be equal to 116. $\frac{6 \times 6 + 14 \times 14}{2} = 116.$

GROWTH OF COTTON IN FRANCE.—*Cosmos* states that M. Arnaud, of Remoulins, has demonstrated that cotton can be grown in the south of France. The expense, beginning with the preparation of the soil, and ending with cleaning and warehousing the cotton, is 800 frs. per *hectare*, which is equal to 24,711 acres. In Algeria the return is 500 or 600 kilogrammes, each of which is rather more than 2½ lb.; and supposing 300 lb. could be obtained in France, it would yield, at 6 frs. per kilogramme, 1800 frs., half of which would suffice for a good profit. The great objection is, in the south of France the plant does not become quite ripe, and the capsules, after being gathered in a closed state, require to be kept in a warm, dry place, until they open of their own accord.

76TH ASTEROID.—M. d'Arrest has discovered this body, which resembles a 12 magnitude star. He proposes to call it Freya. It is the first object of its kind that has been discovered at Copenhagen.

THE SUPPOSED SATELLITE OF VENUS.—We learn from *Cosmos* that M. Haase, of Hanover, called the attention of astronomers, by circular, to the advisability of watching the solar disk towards the end of November and the beginning of December, as he believes the body conjectured to be a satellite of Venus may be a small planet revolving in an orbit, not differing much from that of the great one. When sufficient time has expired to collect the various observations, some new light may be thrown on this curious subject.

AGE OF THE PYRAMIDS.—M. Radau states that Mahmoud Bey, Astronomer to the Viceroy of Egypt, has investigated the structure of the Pyramids, with a

view to discover the object of their erection. He finds the average slope of the Great Pyramid, and of six others at Memphis, to be 52°, and the variation from this mean to be slight. Moreover, the pyramids and funeral monuments which surround them, are placed so as to correspond exactly with the four cardinal points. Now it is observed when Sirius passes the meridian of Gizeh its rays strike upon the south side of the Pyramid, and 3300 years B.C. they must have fallen perpendicularly upon it, and thus, according to astrological speculation, must have exerted their greatest influence. He therefore conjectures that the pyramids were built so as to receive the most complete illumination from the brightest star in our heavens, which was consecrated to Sothis, the celestial dog and judge of the dead. The date of 3300 years B.C. corresponds with Bunsen's calculation, according to which the pyramids were built in the reign of Cheops, in the 34th century before our era, and it also coincides with the Arab tradition that they were constructed three or four centuries before the Deluge, in the year 3716, before the Hegira.

OZONE PRODUCED BY PLANTS.—Mr. C. Kosman has communicated to the French Academy a series of observations, from which he draws the following conclusions:—1. Plants evolve ozonized oxygen from their leaves and green parts. 2. They disengage during the day ozonized oxygen in a greater ponderable quantity than exists in the circumambient air. 3. During the night the difference between the ozone produced in the plants, and that contained in the air, becomes *nil* in the case of isolated vegetation, but where the plants grow thickly and vigorously, this ozone is more abundant than that of the air. 4. Plants in the country evolve more ozone during the day than town plants. 5. From this cause country air is more exhilarating than town air. 6. In the midst of towns, and of a dense population, the night air exhibits more ozone than that of the day, but in proportion as the animal population diminishes, and the vegetable kingdom predominates, the diurnal ozone increases until it exceeds that of the night. 7. The interior of the corollas of plants do not evolve ozone. 8. Inhabited rooms do not usually contain ozonized oxygen.

OXYGENIZED WATER.—M. Chevreul finds that this preparation destroys colours of an organic origin, just as chlorine does, but more slowly.

SIZE OF MICROSCOPIC PRINTING AND WRITING.—Mr. Webb addresses us a note, in which he says he has measured the first *i* in "shilling," as it appears in one of the microscopic cards supplied to our readers, and he finds it "to be approximately the $\frac{1}{300} \times \frac{1}{1000} = \frac{1}{300000}$ of an inch." The specimen which he engraved for us was by no means intended to represent the limit of perfection to which he has brought this curious art, but such as could be easily read with a moderate power by persons of ordinary sight. He sends us the "Lord's Prayer," beautifully printed from copper, in which he states the letters are $\frac{1}{1100} \times \frac{1}{1100} = \frac{1}{1210000}$ of an inch, and he observes in his note, "startling as the above numbers appear at first sight, yet the letters are very large when compared with those which have been cut upon glass, some of which are only the forty millionth of an inch." He adds, "In your September number you mentioned my chapter of St. John. That specimen has been measured by several gentlemen, who all agree in stating it to be the $\frac{1}{31} \times \frac{1}{34}$, or $\frac{1}{1054}$ of an inch. The 4137 letters in that specimen, multiplied by 1054, give 4,360,398 letters to the square inch, while the whole of the Bible and Testament are said to contain only 3,566,400 letters, thus showing that at the rate in which the chapter of St. John is written, the whole Bible and Testament, and more than three-quarters of a million ad ditional letters, would come into the square inch" Mr. Webb also calls attention to the extreme minuteness of the particles of blacklead with which the lines of the finest writing on glass are filled by the gentleman who mounts his specimens. Their size, he says, would require at least ten figures to express it, and such figures are probably only a tenth of the number required to state the dimensions of Dr. Faraday's ruby gold.

BOLIDES.—On the 26th November, about 5 P.M., a large meteor was seen described "as big as two fists," and lighting up a lane near Chiselhurst. On the same date, but at 6 P.M., a gentleman near Broxbourne saw a large meteor

apparently 400 or 500 yards above the ground, first blue, then red, and emitted numerous sparks. The same body appears to have been seen at Peckham, Bath, etc. *Cosmos* states that a few minutes before six this bolide passed over Havre with astonishing rapidity from N. to S., leaving a luminous track behind it. It was also seen at Bolbec, Ivetot, and Rouen; observers at the latter place fancying it fell by the Church of St. Vivien. At Strasburg it was seen about five minutes to five.

Pseudopodia of the Rhizopoda.—The *Annals of Natural History*, No. 60, contains a translation of Professor Reichert's observations on the pseudopodia of *Miliola and Rotalia*, which he obtained alive at Trieste. He states that the pseudopodia, when fully extended, measure six or eight times the diameter af the body, and terminate in filaments so fine that "a perceptible thickening scarcely appears when two or three filaments come together, and apparently pass into one, or when the magnifying power of the instrument is raised from 450 to 700 diameters." He denies the fact of the so-called movement of granules in these organs, and explains it by a "contraction wave formed by a loop advancing along the filament, produced in consequence of contractile movements of the substance invisible to us." He denies that the pseudopodia coalesce or amalgamate on touching each other, although they readily adhere, and ascribes the appearance of a "sarcode net" to apparent anastamoses arising from adhesion.

The Animal and Float of Ianthina.—Mr. A. Adams, writing in *Annals of Natural History*, describes the beautiful *Ianthina*, or ocean snail, as quite blind, and having the large horny mandibles, and the rounded extremity of the tongue, furnished with sharp, curved, slender teeth. It chiefly feeds on Physalia Porpitæ and Velellæ. The Ianthina is remarkable for floating shell downwards in the water, and Mr. Adams tells us that the anterior part of the foot forms a "shallow cup which embraces the smooth anterior rounded end of the float. When the animal wishes to bring its head to the surface of the water, this part of the foot is made to glide over the back of the float. Thus the animal can raise and lower itself at pleasure by means of its own float." The floats are formed of a mucous film containing air, and when cut with scissors the animal descended to the bottom of the vessel in which it was confined, and did not make a new one.

The Supposed Minute Vertebrate.—Mr. Spence Bate points out the probability of the supposed minute jaw found by Dr. Wallich in St. Helena mud being the last joint of the leg of a small crustacean, and Dr. Wallich sends a fresh letter to the *Annals of Natural History*, giving reasons for thinking it—as Mr. Busk conjectures—a valve of a pedicellaria from an echinus.

Mr. Hincks on the Medusæ of Hydroid Polyps.—The Rev. Thomas Hincks gives two drawings, with descriptions, in the *Annals of Natural History*, showing that the medusa, or "*gonozoid*," as he prefers to call it, "of the *Stauridia producta*, is identical with that of the *Coryne eximia, a member of a distinct genus*." The reader who is not acquainted with the curious modes of reproduction and development belonging to these creatures, is referred to our article on the "Origin and Transformation of Animals" (September No., p. 95).

De Candolle on Species.—In an article on the *Cupuliferæ* in the *Bibliothèque Universel*, M. Alphonse de Candolle observes, "hereditariness is an attribute of races as well as of species, to cite an evident example, the Jewish people have a certain hereditary configuration, which they preserve under all climates and influences of nutrition, without any one pretending that they constitute a species. Non-hereditariness may overthrow a pretended species, but hereditariness, even when it appears to be indefinite, does not prove the existence of a species."

Secchi on the 2nd Comet of 1862.—In a letter to M. Elie de Beaumont, M. Secchi gives an interesting account of this comet, which may be taken in conjunction with that already furnished to our readers by Mr. Webb and Mrs. Ward. He says the opposite directions taken by the sheaf-like streams of luminous matter, indicated two fixed centres of eruption. "The tail was simple until the two reversed jets were well developed, so that no doubt could remain that it was really these

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nebulosities which, in reversing themselves, produced the tail." The periodicity of the jets at first suggested a rotation of the comet about an axis, but the idea was not confirmed by observation. The light of the nucleus and of the *aigrettes* was only polarized once, on the last day on which such an observation was possible, and then very feebly. The nebulosities, on the contrary, were always strongly polarized. These facts indicate a different molecular condition, and M. Secchi suggests that the nucleus and the aigrettes may have been formed of vapour analogous to our clouds, which do not polarize, while the nebulosities had passed into a state of gas which polarizes like our atmosphere. He adds, "We might also admit that the nucleus and the aigrettes were incandescent, but the supposition is a little difficult. After the perihelion passage there appeared vestiges of paraboloid surfaces enveloping the sheaves of light, as if the matter was being deposited in layers as the comet cooled."

SECCHI ON MARS.—In 1858, M. Secchi found the appearance of Mars differ considerably from the drawings of Maedler and other astronomers. Now, the planet has returned to its former aspect, and, instead of exhibiting large complicated solar spots, showed them to be reduced to a small circle, as in Maedler. The great spots had given place to rose-coloured surfaces, traversed by blue canals, as represented in Secchi's picture of 1858. From these changes he thinks no doubt can remain that the polar spots consist of snow, or condensed clouds, which the summer heat of the planet melts. The red surface he regards as land, and the blue canals as water.—*Comptes Rendus.*

VOLCANIC HAIR.—M. Rambosson communicates to the French Academy some facts relating to the volcano in the Isle of Reunion, and states that in the eruption of 1860 as in that of 1812, it poured forth a shower of dark cinders and of long flexible filaments of glass-like golden hair. Similar filaments were seen by Sir W. Hamilton emitted by Vesuvius in 1779.

ANALYSIS OF AIR.—In his pamphlet on "Air and Water," Mr. Condy points out the facility with which air may be tested for organic impurities by placing in the required spot four or more small white saucers, each containing an ounce of distilled water, and severally one, two, three, four, or more drops of his Patent Ozonized Water, or Disinfecting Fluid, reduced by addition of two parts of water. The rate at which the pink colour of the permanganate disappears, indicates the proportion of impurity present. If during a night or day the colour vanishes in the saucer containing four drops, he states that the impurity verges on positive pollution.

NEW USE OF DIAMONDS.—It was proposed some time ago in *Cosmos* to employ rough dark diamonds in the perforation of rocks, and that journal now states that M. Leschot has used a perforator formed of a tube terminating in a crown of these diamonds, and succeeded in making a hole in granite in one hour which would have taken two miners two days. The diamonds were not injured in the process.

EXPERIMENT WITH SULPHURETTED HYDROGEN.—*Cosmos* says, "Bring some drops of bromine in contact with sulphuretted hydrogen, and you will see the volume of the gas doubled at the moment the sulphur is deposited."

A FOWL WITH BLACK PERIOSTEUM.—Dr. Miche, dining with some friends on a Cochin China fowl, noticed that the covering of its bones was quite black. He accordingly sent the skeleton to M. Flourens, who was able to exhibit to the Academy a similar skeleton of a common fowl. The bones themselves were white. Six chickens out of twelve having the same parents exhibited this peculiarity, and the flesh of the only one killed was dark and ill-flavoured.